

**POST-DELISTING MONITORING STUDY
FOR *HOWELLIA AQUATILIS* (*WATER HOWELLIA*) IN MONTANA:
TWO-YEAR BASELINE ASSESSMENT**



Prepared for

**U.S. FOREST SERVICE
REGION 1 - MISSOULA
FLATHEAD NATIONAL FOREST – KALISPELL
MONTANA**

**U.S. FISH AND WILDLIFE SERVICE
MONTANA ECOLOGICAL SERVICES FIELD OFFICE
HELENA
MONTANA**

Prepared by

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HELENA, MONTANA**

November 25, 2024



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Cooperative Endangered Species Conservation Fund
Agreement # F22AP03727

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Cover Photographs:

A vernal pond with Howellia aquatilis (Water Howellia) in the Swan Valley, Montana.

Photographer: Scott Mincemoyer.

A close-up of Water Howellia in the Swan Valley, Montana.

Photographer: Rebecca Durham.

POST-DELISTING MONITORING STUDY FOR *HOWELLIA AQUATILIS* (WATER HOWELLIA) IN MONTANA: TWO-YEAR BASELINE ASSESSMENT

1.0 INTRODUCTION

Howellia aquatilis (Water Howellia) is an aquatic plant that is endemic to the Pacific Northwest (MTNHP 2024). In Montana plants only grow in the Rocky Mountain Wooded Vernal Pool Ecological Systems¹ which is found within the Swan Valley (**Figure 1**). In 1994 it was listed as Threatened under the Endangered Species Act (ESA or Act) and removed from listing on June 16, 2021 (86 FR 31955; USFWS 2021). This action triggers the use of Section 4(g)(1) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.), which requires the U.S. Fish and Wildlife Service (USFWS) to work cooperatively with the States to implement a monitoring program for not less than 5 years. The intent of a post-delisting monitoring plan is to validate delisting assumptions and verify that the species is self-sustaining without the protections afforded under the ESA (16 U.S.C. § 1531 et seq.). The *Post-Delisting Monitoring Plan for Water Howellia* (*Howellia aquatilis*) was finalized by the USFWS in 2020 and specified that two consecutive years of monitoring must occur at three distinct time intervals during a 15-year period (USFWS 2020).

Figure 1. *The distribution of Water Howellia Species Occurrences (green polygons) within its statewide range (purple polygon) in Montana.*



1.1 Need for Post-Delisting Monitoring

The primary need for Post-Delisting Monitoring is to determine if Water Howellia populations can sustain themselves without ESA protections. In addition, the Montana Natural Heritage Program (MTNHP and the Flathead National Forest (FNF) have secondary needs that are fulfilled by post-delisting monitoring:

¹ Montana Field Guide: https://fieldguide.mt.gov/displayES_Detail.aspx?ES=9162

- State Conservation Status Rank (S-Rank) and Species Occurrence Rankings:

The MTNHP is responsible for maintaining current and accurate S-Rank and Species Occurrences Rankings (also known as Element Occurrence (EO) Rankings). Both rank types are used by federal and state agencies, non-governmental organizations, and NatureServe in management planning and projects, assist in species listings by agencies, and guide other conservation actions. The SO Rank is particularly vital for management because it assesses the occurrences' population size, health, reproductive success, and habitat condition to determine the SO's viability (excellent, good, poor, extirpated). Upon completing the two consecutive years of field-based monitoring the MTNHP botanist will be able to update the SO Rank for the sites monitored.

- Conservation Strategy for *Howellia aquatilis* (USFS 1997):

The FNF and Forest Botanist manage the majority of known SOs and potential habitat for *Howellia aquatilis*. The conservation strategy identifies the secondary need to ensure that viable populations of all native plant and animal species are maintained and the forest plan commits to conserve and monitor this plant (USFS 1997; USFS 2018). Implementing this post-delisting monitoring plan helps the FNF achieve this directive and informs them of when and where special management may be needed, or not.

1.2 Purpose for Post-Delisting Monitoring

The purpose of this monitoring project is to survey and collect two consecutive years of Water Howellia population data from a minimum of 30 ponds in Montana as outlined in the Post-Delisting Monitoring (PDM) Plan (USFWS 2020). The consecutive 2022-2023 fieldwork starts the 15-year monitoring window and sets the baseline conditions to determine a trend (increasing, decreasing, or stable) through 2036. To fulfill the purpose and need, baseline conditions were collected on Water Howellia and Reed Canarygrass (*Phalaris arundinacea*) population sizes, summer and autumn pond hydrology, ambient temperature, and other factors at 50 randomly stratified Species Occurrences (SOs; occurrences; ponds) and 4 non-randomized SOs in 2022 and 2023.

1.3 Life Cycle of Water Howellia

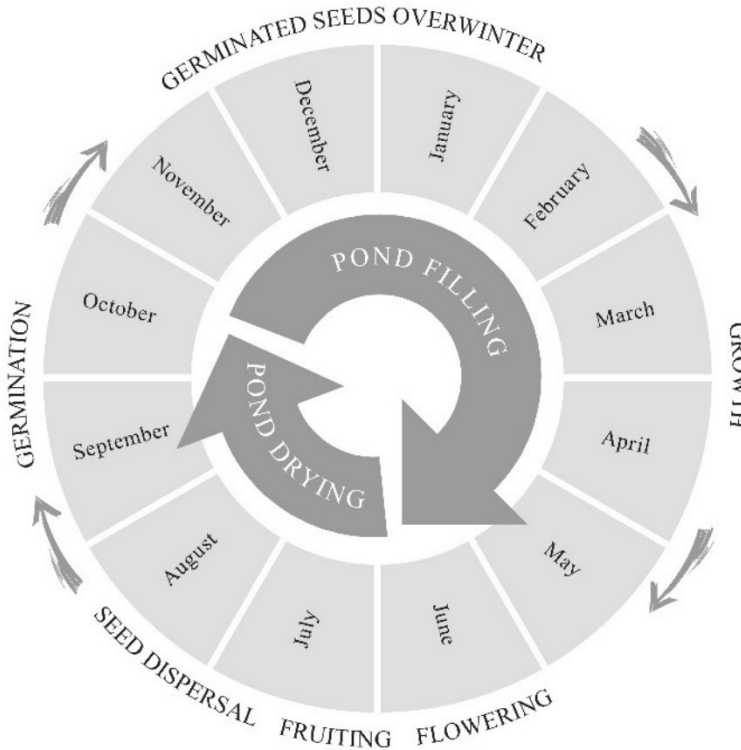
Knowledge of Water Howellia's life cycle and vernal pond hydrology is useful for understanding the PDM protocol. An overview of Water Howellia's complex and fascinating life cycle is presented in this report and more information is found on the species' profile in the Montana Field Guide²

Water howellia is a winter annual (**Figure 2**). Seedlings germinate in fall and overwinter under snow. In early spring, ponds fill with water from snow melt, rain, and groundwater inflow. With inundation, seedlings grow into mature plants through summer. Mature plants can produce two types of flowers. Underwater flowers develop but do not open and are self-pollinated (cleistogamous). Cleistogamous flowers reach anthesis in late June. Stems that reach the water's surface produce flowers open and cross-pollinated (chasmogamous). Chasmogamous flowers bloom at the water's surface from about mid-July through the end of the growing season. Seed dispersal starts in June from cleistogamous flowers and extends through the growing season from chasmogamous flowers (USFWS 1996). Though spread of seeds between ponds by waterfowl or other animals may be possible, it has not been documented (Mincemoyer 2005; Schierenbeck and Phipps 2010). As the pond draws down, seeds mature, and plant senesce; plants die with complete evaporation of the pond. Mature seeds that have settled in the pond sediments during the growing season germinate only after exposure to air and fluctuating temperatures in autumn; this breaks seed dormancy (Lesica 1990). Germinated seeds root in the substrate and suspend growth through the winter until ponds begin to fill in early spring. Population size in a given year is

² *Howellia aquatilis* - Montana Field Guide: <https://fieldguide.mt.gov/speciesDetail.aspx?elcode=PDCAM0A010>

affected by the extent to which the pond dried out at the end of the previous year. Due in part to this dependence, population size varies widely from year to year.

Figure 2. The life cycle of *Howellia aquatilis* (Water Howellia) and a simplified hydrological cycle of vernal ponds as researched in Montana (Shelly and Pipp 2016).



2.0 METHODS

The monitoring project was carried out by members of the Montana Committee representing the MTNHP and US Forest Service (USFS) (Region 1 and FNF), as defined by the PDM Plan (USFWS 2020). Through a competitive ESA-Section 6 grant, funding was awarded to the MTNHP to lead the monitoring effort and supported with in-kind funding by the USFS (Region 1, FNF, and Lolo National Forest). Project planning, protocol development, and a Survey123 data collection tool were co-developed in 2022 by the FNF Forest Botanist (Chantelle Delay), MTNHP Data Systems and Sciences Lead (Braden Burkholder), and MTNHP Botanist (Andrea Pipp). A virtual meeting, led by the MTNHP botanist, was held each year prior to the field season to coordinate the project's logistics, field equipment, and topics for discussion. Prior to field work in each year, the final Survey123 data collection forms were uploaded onto agency tablets and other GPS-enabled mobile devices.

This baseline report provides the PDM protocol used in Montana. It is to be used for the next two rounds of 2-year consecutive monitoring in years 7-8 (2028 to 2029) and 14-15 (2035 to 2036) of the 15-year timeframe. This baseline report provides detailed instructions that a crew of botanists, biologists, and others who possess good botanical plant and field skills could implement.

2.1 Water *Howellia* Occurrences in Montana

In Montana, Water *Howellia* is only known to occur in the northwestern portion of the state, within the Swan Valley. Most occurrences are on lands managed by the Flathead National Forest. A smaller number

of occurrences are on Montana State Trust lands managed by the Department of Natural Resources and Conservation, private lands, and other ownerships.

In 2022, there were 221 documented Water *Howellia* Species Occurrences in Montana (MTNHP 2022). The MTNHP acquires observation data on Water *Howellia* and tracks the plant at the pond level as a Species Occurrence (SO; occurrence; pond). Most occurrences are discrete vernal ponds, except during high water when some could have surface connections, and a few are old river oxbows. Ponds vary in size from 0.03 acre to 13 acres, with the vast majority being under 1 acre. Most ponds and their 300-foot buffers are managed by a single landowner (see USFS 1997). Some ponds or buffers are managed by multiple landowners because they are bisected by property boundaries.

2.2 Determining the Sample Population for Monitoring

The PDM Plan (Plan) requires that a minimum of 30 ponds be randomly selected to monitor in Montana (USFWS 2020). Further, the Plan specifies criteria for selecting this minimum sample size, as follows:

- 1) history of monitoring - opportunity to making meaningful interpretations of data sets that are already in place,
- 2) range of disturbance factors represented by pond buffers - fire, road, vegetation treatments, and others,
- 3) ability to capture geographic and elevational distribution across the metapopulation, and
- 4) reasonable accessibility.

2.2.1 Baseline Monitoring Population

The baseline monitoring population consists of Water *Howellia* SOs that got monitored consecutively in 2022 and 2023 using the PDM protocol for Montana. It consists of PDM Water *Howellia* SOs that were selected through a stratified random process and additional Water *Howellia* SOs that were selected with intent and not from a randomized process.

2.2.1.1 Stratified Random PDM SO Sample

A stratified-random sampling approach was used by MTNHP staff to select a minimum of 30 ponds (SOs; occurrences) to monitor. A previous project analyzed Montana's 221³ occurrences from 1978 to 2017 and provided the pertinent information needed for this project to stratify SOs based on past disturbances and landownership type (MTNHP 2016; Pipp 2017). To this dataset, newer data from 2018 to 2021 was added. For PDM, the complete dataset of 221³ Water *Howellia* occurrences information from 1978 to 2021 was queried by landownership. Only ponds with their 300-foot buffers that occur entirely on public lands managed by the USFS, State of Montana, or TNC were eligible for monitoring. Eligible sites (300 foot-buffered SO) were then stratified by the following criteria:

- 1) Geographical Distribution. Water *Howellia* SOs seemed to cluster into northern, eastern, western, or southern zones within their state range (**Figure 1**).
- 2) Previously Monitored or Not Monitored. Previous monitoring studies included the USFS 1988-1997, USFS 1998-2007, TNC 2010-2012, and "other" which are predominantly MTNHP monitored sites.
- 3) Disturbed or Undisturbed Pond Buffer. Disturbance types documented within the pond's 300-foot buffer between the early 1900s and 2014 included forest stand treatments, roads, cattle grazing, and fire (see Pipp 2017).
- 4) Elevation. Although evaluated, the variability in elevation was too minimal to use for stratifying.

³ In 2022 the MTNHP botany database contained information on 221 Water *Howellia* SOs.

The goal was to obtain a stratified, random dataset of 50 SOs, to ensure that at least 30 ponds would get monitored. The stratification consisted of 16 possible outcomes for ponds managed on public lands (criteria 1-3 above). From this stratification, 50 Water Howellia SOs were randomly selected. **The 30 SOs that were stratified and randomly selected represent the dataset that must be monitored, assuming no attrition, through the 15-year span in order to detect a state population trend. However, 50 SOs were revisited in order to increase the sample size, improve statistical power to detect a trend, and account for possible loss of sample sites due to problems that arise during fieldwork and from future changes that affect access to ponds, landownership, habitat, land use, and other causes.** Monitoring all 50 SOs also improves the utility of the monitoring effort to achieve the secondary goals (see Need for Post-Delisting Monitoring).

2.2.2.2 Non-random Additional SO Sample

Opportunities to monitor additional Water SOs came about in 2022 and 2023 and could occur in future rounds of PDM. The PDM protocol for Montana was taught to student groups and used at sites selected for their ease to access and close proximity. Therefore, these sites are not randomly selected and cannot be used in statistical analyses. However, they do increase the sample size and can provide more information.

2.2.2 Sampling Unit

The method and sampling unit developed by the Flathead National Forest was also used for post-delisting monitoring (Mantas 1998 and 2000). Each Water Howellia SO is a defined pond or old river oxbow that differ in size and shape, which is problematic for analyzing data. This method uses the quarter-acre section as a standardized sampling unit detect trend. Each monitored pond was divided into quarter-acre sections of square to rectangular shapes (**Figure 3**). The quarter-acre section maps for previously monitored ponds were retained, and only re-mapped if they partitioned the pond into triangular slices, like a pizza. The quarter-acre sections were overlaid onto the pond's aerial imagery and used in fieldwork. The rectangular to squarish quarter-acre sections become the permanent sampling unit (not the pond) upon which to collect field data, analyze statistical results, and determine the Water Howellia population trend through the 15-year monitoring period.

2.3 Field Data Collection Tools

Using the PDM Plan and methods developed by the FNF, the PDM protocol for Montana was refined to employ newer data collection technology and develop logistics for assembling equipment, field crews, and other needs. Refer also to the *Data Review and Analysis* section of this report.

2.3.1 Data Collection Forms

Data collection tools in digital and paper formats were developed for summer and autumn revisits to Water Howellia ponds:

- Digital summer (*Howellia aquatilis* Monitoring) and autumn (*Howellia* Fall Dry Transects-2022 and *Howellia* Surface Water Survey-2023) monitoring forms were developed by MTNHP staff for professionals to use with Survey123, a mobile app. The Survey123 forms when loaded onto a GPS-enabled tablet or phone allows users to track their location, navigate to the target SO, collect plant data, map plants, and photograph. Data is saved as a draft and proofread by the observer before electronically submitting to MTNHP's ArcGIS Online (AGOL) account. **NOTE: The Survey123 summer and autumn forms are only available electronically from MTNHP.**
- Written monitoring instructions and a single paper version that combines the summer and autumn monitoring forms were developed. The paper version serves as a backup - when one's electronics fail - and to used by students and other non-professionals to collect data (**Appendix A**). The paper version is used to collect plant data and requires surveyors to also have a camera for documenting plants, habitat, and pond conditions and a GPS or printed maps to map plants and other landmarks.

2.3.2 Temperature Loggers

The PDM Plan recommends that temperature loggers be used to record ambient air temperature where water depth is recorded. The purpose is to measure air temperature through the growing season as it is one environmental factor that influences pond drying. Due to the timing of funding and fieldwork, temperature loggers were not available for use in 2022. In 2023, iButton temperature loggers were installed adjacent to three ponds in the northern (SO-ID 5000108-Cilly Creek), eastern (SO-ID 5000018-Condon Loop), and southern (SO-ID 5000038-Kraft Creek) areas of the study by a FNF botany crew member. The iButton loggers were placed in a plastic tab and nailed to a tree using specific guidelines (**Box 1**). The iButton loggers were set to collect ambient temperature at five times in a 24-hour period from May 10th to November 16th in 2023. They were retrieved by a FNF botany crew member on November 17th and sent to the MTNHP botanist.

In future monitoring rounds, the iButton temperature loggers should be placed in the same location at the three ponds used in 2023. GPS coordinates are archived in the project files at the FNF and MTNHP.

Box 1. Guidelines for placing iButton temperature loggers adjacent to Water Howellia ponds.

- Find a solid, live tree that likely represents the air temperature around the pond.
- Place the ibutton about 5-6 feet above the ground surface.
- Try to place the iButton where an animal would not likely damage or remove it.
Example: Place it on a smaller branch as opposed to a tree trunk.
- Do NOT place the ibutton where there is direct sun. It needs to be protected from direct sun, or else it will give false readings.
- If possible, find a location that is likely to be accessed during monitoring.
- Mark the location with a GPS coordinate.
- Optional: Hang flagging near to the iButton to help relocate it at the end of the season.
- Do not directly put flagging on the tree where the iButton is attached. This could become an attractant for people or animals or could interfere with temperature recordings.

2.3.3 Other Equipment and Lodging

The USFS gave the PDM crew permission to station themselves at the USFS Condon Work Center in Condon, Montana. The crew camped (tent, trailer, or RV) on the compound, but was able to use the kitchen and bathroom facilities at the cookhouse and a residence home. This created a very workable situation for carrying out the project. Crew members were supplied by their agency and prepared with the following necessary gear:

- Tablets loaded with the Survey123 app and *Howellia aquatilis* Monitoring and *Howellia* Surface Water Survey-2023 electronic forms. Tablets should also have waterproof cases.
- Digital camera and GPS if using the paper forms
- Hip waders with sock feet, boots, or sandals/socks for safety and protection. Ponds have leaches!
- Bear Spray for each person. This is grizzly bear country!
- First Aid Kit: personal and/or vehicle
- Radios or phones for communication; Cell coverage is poor and spotty.
- Basic field gear: backpack, compass, pens/pencils/markers, hand-lens, plant identification book(s), notebook, rain gear, proper foot gear, maps, etc.
- Water and food.
- Water Howellia SO packet. Provided by MTNHP after assigning ponds to crew members.
- Forest and road maps, digital and/or paper versions, with targeted Water Howellia SOs.
- Personal cell phone (optional)

The MTNHP botanist prepared a packet for each targeted Water Howellia SO to monitor. The packet consisted of the following contents tucked into a plastic sleeve to protect against rain, water, or getting lost:

- A printed map showing labeled SO pond and quarter-acre section boundaries, north arrow, and photo scale overlain on an aerial image. Crew members liked having the aerial map for navigating to the correct pond and seeing landscape features like logs.
- A printed map showing labeled SO pond and quarter-acre section boundaries, north arrow, and photo scale with a blank background. Crew members liked having this pond map because it was easy to write notes on.
- A printed copy of the instructions and paper monitoring form. Monitoring form should be printed on rite-in-the-rain paper; however, the plastic sleeve provides protection.

2.4 Post-Delisting Monitoring Fieldwork Protocol

The PDM protocol was jointly conducted by 10 to 15 professional botanists and biologists working for the USFS-Region 1, FNF, USFWS, and MTNHP in 2022 and 2023. Additional professional field assistance came from the Lolo NF in 2022 and from Iris Consulting in 2023. The goal was to implement the protocol at a minimum of 30 SOs to a maximum of about 50 SOs. Summer monitoring took place during the first full week of July after the July 4th holiday in 2022 and 2023. Autumn monitoring took place in mid to late September in 2022 and 2023. The summer session collected data on the presence and abundance of Water Howellia, Reed Canarygrass, aquatic vegetation, and noxious weeds; pond hydrology (surface and/or depth of water); threats to ponds and their 300-foot buffers; and other information. The autumn session collected data on pond hydrology (surface and/or depth of water); presence and abundance of noxious weeds; threats to ponds and their 300-foot buffers; and other information.

A cooperative effort between the MTNHP botanist and Swan Valley Connections⁴ allowed us to use the protocol in programs designed to get young people involved in the natural sciences. In 2022 and 2023 students enrolled in the Mission Mountains Youth Crew (MMYC) Program⁵ were taught about Water Howellia, vernal pool ecology, and how to monitor the plant. In 2023, students enrolled with the Amskapi Piikuni – Montana Conservation Corps⁶ were also taught about the plant, ecology, and how to conduct the monitoring. The intent was for students to use a paper monitoring form, camera, GPS-unit, hip waders, compass, and other necessary gear to conduct the monitoring at additional Water Howellia SOs. The additional SOs were selected based on ease of access and location to one another in order facilitate group-collected fieldwork. At the additional Water Howellia SOs, students conducted the summer session and professionals conducted the autumn survey to ensure that the entire protocol was completed.

2.4.1 Training

At the beginning of each monitoring session (summer and autumn) and in each year (2022 and 2023), the crew was trained on the PDM protocol. Training is essential because it calibrates the crew on how to search for and collect data to help ensure accurate information. Training took place at Water Howellia SO 5000044, which has easy access and adjacent parking. The MTNHP botanist led the training, but information was facilitated by several crew members who have extensive past monitoring and survey experience with Water Howellia. Training content included information on the PDM Plan, purpose and goals of monitoring, how to complete the Survey123 data forms and paper form, safety, and survey techniques (**Box 2**).

⁴ Swan Valley Connections: <https://www.swanvalleyconnections.org/>

⁵ Mission Mountains Youth Crew Program: <https://www.nationalforests.org/regional-programs/northern-rockies/mission-mountains-youth-crew-program>

⁶ Amskapi Piikuni – Montana Conservation Corps: <https://www.mtcorgs.org/joinmcc/amskapi-piikuni-partnership/amskapi-piikuni-partnership.html>

Box 2. Content for the Post-Delisting Monitoring training.

- Brief history on listing and delisting of Water *Howellia*
- Purpose and need of the PDM Plan
- Purpose and goals for the specific monitoring session (summer or autumn)
- Plant identification of *Howellia aquatilis*, *Phalaris arundinacea*, various aquatic and terrestrial noxious weeds, and various look-alike plants
- How to conduct the pond survey; search tactics for *Howellia aquatilis*, *Phalaris arundinacea*, and noxious weeds
- Estimating *Howellia aquatilis* abundance and group calibration of abundance codes
- How to complete the data fields in the Survey123 customized electronic and forms
- How to monitor for pond hydrology, aquatic/emergent vegetation, threats, and other data

2.4.2 Accessing the Water *Howellia* SO

Navigating on public land to the correct Water *Howellia* pond can be tricky. Useful navigation tools included: GPS unit, Survey123 monitoring form, FNF map, and landownership map. In 2022 and 2023 field crews compiled access routes and tips to many of the ponds; they are recorded in a Microsoft (MS) Powerpoint file that is available from the MTNHP botanist (MTNHP 2023). Ponds were accessed directly by vehicle on public roads or by foot on trails and public roads behind locked gates. It was suggested that using mountain bikes could be efficient, but no one toted their bike to the forest.

2.4.3 Field Monitoring Procedure

Ideally people work in pairs to access and conduct monitoring. The *Howellia aquatilis* Monitoring and *Howellia* Surface Water Survey-2023 in Survey123 are used to collect data, map locations, and photograph conditions. Alternatively, hardcopy monitoring forms, a camera, and a GPS unit, or similar devices, can be used to collect data, photograph, and map locations. Survey with waders or similar gear to protect yourself from leaches, pointy sticks, etc.

Each pond is tracked by a Species Occurrence number (SO-NUM) and identification number (SO-ID). Each pond is divided into sections that are approximately 0.25 acre in size, and assigned a consecutive number (S1, S2, S3, etc.), which is drawn on the hardcopy map of the pond.

2.4.3.1 General Pond Information

On the form complete the following fields as follows:

SO-ID	Obtain from the provided pond map.
Camera/GPS	If <u>not</u> using Survey123 app, record the model/description to match photos with data.
Observer's Name(s)	Use the full first and last names for the primary and secondary observer(s). For group -based monitoring use the official group's name
Observation Date	Record the month, day, and year when the pond was monitored.
Start and End Times	Record the time when monitoring started and ended. Survey123 will automatically complete start time and date, which can be manually changed.
Datum	Survey123 uses WGS84. All devices should be set to WGS 84. However, if this is not possible with a tablet, phone, or GPS unit then record the coordinate system (WGS84, NAD,27, etc.) used to map points and polygons.
SO Located?	Indicate if you found the SO or not. If unsure mark "no" and explain. Be honest.

Latitude/Longitude	Write the coordinates or mark a point to indicate your general location at the SO. This helps assess if the correct SO was found or not located.
Weather	Concisely describe the weather. This helps provide context that might explain the quality of data collected, ability to find the plant, etc.
Number of Sections	Survey123 will auto-populate the number of sections once the SO number is typed in. If collecting data on an additional Water SO then manually type in the number of pond sections displayed on your map.
Lock Site Info Above	If using Survey123 form, click ‘yes’ to prevent data loss if the tablet is dropped or data collector falls.

2.4.3.2 Surveying The Pond Section For Plants

Meander through a section to search for *Howellia aquatilis*, *Phalaris arundinacea*, total Submergent Aquatic Vegetation (*minus Howellia aquatilis*), and total Emergent Aquatic Vegetation until you can make a confident determination of abundance using the categories provided on the form. NOTE that *Howellia aquatilis* abundance is determined by plant number and *Phalaris aquatilis*, Emergent, and Submergent vegetation is by percent cover. In each case the specific Section equals 100%. Refer to the hardcopy monitoring form for guidance on *Howellia* numbers; counting plants is only needed for initially calibrating one’s eyes. The following information is assessed for a single section; Pay close attention to section boundaries as you meander through the pond.

Submergent Vegetation includes all plant material, excluding *Howellia aquatilis*, that grows below the water’s surface, and without regard to the species’ growth form to make the method more repeatable. Submergent Vegetation provides an idea of competition in the water and ability to track changes in underwater vegetative changes. The protocol incorporates the following notes:

- Note 1: Submergent percent cover was collected at the pond level in 2022 and at the section-level in 2023. Collecting this data at the section level improves its ability to be repeatable and its utility to be used with other section-level collected data.
- Note 2: The stems of emergent vegetation that grow below the water's surface are included in the submergent percent cover value.
- Note 3: If the pond section is dry or without a substantial depth of water then record submergent vegetation as "0" if the pond is barren of plants or “NA” when plants occur without surface water.

Emergent Vegetation includes all plant material that is on or above the water’s surface, and without regard to the species’ growth form to make the method more repeatable. Emergent vegetation is a measure of what grows on and above the water surface, and provides the ability to track ‘above-water’ vegetative changes. Above surface vegetation could create competition, such as for light, or could provide protections, such as from ambient temperature fluctuations. The protocol incorporates the following notes:

- Note 1: Emergent percent cover was collected at the pond level in 2022 and at the section-level in 2023. Collecting this data at the section level improves its utility to be used with other section-level collected data.
- Note 2: If the pond section is dry or without a substantial depth of water then record all plants as “emergent”. Record the percent cover for that section as "0%" if the pond is totally void of vascular plants.

Aquatic Vegetation Assessment Comments: Write comments that pertain to emergent and submergent vegetation.

2.4.3.3 Mapping Plants and Other Features

Draw either on the hardcopy pond image/aerial or sketch in the Survey123 form where Water Howellia and Reed Canarygrass plants are generally found in the SO.

In the Survey123 form, check sketch and then tap on the sketch symbol to open the pond map (**Figure 3**). Use the following features to zoom and draw a general polygon where HOAQ (*Howellia aquatilis*) and/or PHAR (*Phalaris arundinacea*) occur:



Tap symbol to zoom and move the image to where you want to draw.



Tap to create polygon and then choose HOAQ or PHAR. Tap to create polygon.



Tap to save polygon, and note the symbol changes to only a checkmark.



Tap to undo and re-do a past action, respectively.



Once saved or to exit, tap the back arrow to return to the form.

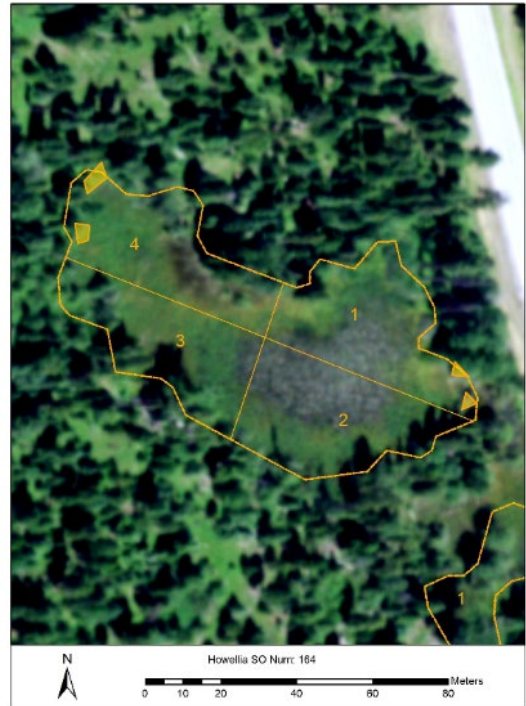


Figure 3. A Water Howellia Species Occurrence (SO; pond) and its four quarter-acre sections. General locations of Water Howellia (hatched polygons) were mapped by the observer in the Survey123 app.

2.4.3.4 Pond Site Information

After all pond sections have been surveyed, complete the following fields:

Water Clarity: Select the best category to describe how clear the pond water is:

- 0 = Clear
- 1 = Faintly Hazy / Cloudy
- 2 = Murky
- 3 = Opaque
- 4 = Dry (no water)

Cattle Use: Select the best category to describe if cattle use was observed. Use includes presence of cattle, their hoof-prints, or signs of use as follows:

- 0 = No Cattle Presence/Use
- 1 = Light Cattle Presence/Use
- 2 = Heavy Cattle Presence/Use

Howellia aquatilis Phenology: Check all phenological conditions that you observed in the pond, as follows:

- Surface flowers
- Underwater flowers
- Vegetative (leaves/stems) material only
- Fruits

2.4.3.5 Photographs

Photographs that capture the following elements are needed to help document presence, accuracy in identification, changes in site conditions, and to relay information gained by the observer to others. NOTE the following:

- The Survey123 form has specific sections for capturing *Howellia aquatilis*, *Phalaris arundinacea*, and site types of photographs. In other words, try not to purposely photograph “pond habitat” in the section for photographing *Howellia aquatilis*.
- The paper form requires a description of what the photo captures, azimuth (if pertinent), and a latitude / longitude location from where it was taken.

Site Photographs

Take 2-5 photographs to capture the pond, habitat, and hydrological conditions. IDEALLY, each pond should be photographed from 2-4 cardinal directions by standing near the edge and shooting towards pond center. However, this is often not practical. Thus, strive to document the site from the places where it was photographed in previous monitoring efforts. **To ensure people take photographs at places, azimuths, and angles similar to those taken in 2022-2023, crew members should have a copy of these photographs in the field.** For each photo, complete the following information:

Location of Photo: Record on the paper form or map the location where photo was taken.

Direction of Photo: Record on the paper form or select the cardinal direction that best matches the direction that the photo faces.

Pond Section: If photo is documenting a quarter-acre section then record or click the section number.

Comments: In the comment box, write a description of what the photo captures.
Write other comments pertaining to what is being photographed, if necessary.

NOTE: Although there are options to re-name a photograph, do **NOT RENAME the photo; the software is formatted to pull information from other fields to create the file name;** you will not see the actual formatted file name.

Plant Photographs

Under the appropriate subsection in the Survey123 form for the targeted plant, take at least one photograph to document that the correct plant was found. Be sure to capture at least one identifiable characteristic. In the comment field write at least one observed characteristic that cannot be photographed. Targeted plants include Water Howellia, Reed Canarygrass, specific noxious species, or other species. If warranted, take additional photos of the plant (not habitat).

2.4.3.6 Weeds

Survey for invasive, noxious, and problematic non-native plants (weeds). Write in or check the box for any that appear in the list on the forms. For those not listed check “other” and provide the name in the comment box. Photograph the plant along with its identifiable characteristics. Write in the comments any characteristics that you observed but could not photograph. For example: Found black hairs on the sepals.

NOTE: Aquatic exotic and noxious plants should be surveyed for within each pond section.

2.4.3.7 Water Assessment (Pond Hydrology)

Assess the amount of surface water present in each section. Determine the location of the high-water mark. Glistening soils indicate saturation, but is not considered surface water. Human or animal footprints that fill in with water are not considered surface water. Write any necessary comments about hydrology or surface water.

2.4.3.8 Summary of Survey

Record the time when you complete the survey. Record the total time spent surveying by calculating the survey time by the number of surveyors. Write any final comments about any aspect of the monitoring.

2.5 Monitoring Data Storage and Analysis

All monitoring data is archived at the Montana Natural Heritage Program and is publicly available for the purpose of stewardship. All monitoring data, photographs, and reporting are shared with the USFWS and USFS (Region 1 and FNF). Observation-level data on species are also added to the MTNHP Botany Database and are made available through Map Viewer, Montana Field Guide, and other applications.

2.5.1 Data Storage and Sharing

All final field data, photographs, and reporting are submitted to the USFWS, USFS, and archived at the MTNHP. Major project products (final report, final 2022-2023 Water Howellia PDM dataset, and final photographs) are submitted to the USFWS through GrantSolutions; the report is also submitted directly to the USFWS - Montana Ecological Office. Data is shared with the USFS through email and various apps for sharing large datasets.

Monitoring data collected using Survey123 is electronically submitted to MTNHP's AGOL account. MTNHP staff examines it for any omissions and other quality control reviews. Monitoring crews are reminded to submit all data within a month of collecting. By November of each monitoring year, the entire year's dataset collected through Survey123 is exported from AGOL into a MS Excel file with multiple linked spreadsheets. Data collected on paper forms are scanned and stored in the botany project files. All data from digital and paper collection tools are combined to create the Final 2022 to 2023 (Baseline) Water Howellia PDM dataset. This final baseline dataset is archived to retain the data as it was generated. All field collected data is reviewed for accuracy and completeness by the MTNHP botany staff. The Final 2022 to 2023 Baseline Dataset that has been cleaned-up to correct or adjust for errors, misspellings, coding problems, etc. is archived. Final statistical analyses and data summaries are also archived.

All components of the Final 2022 to 2023 Baseline Dataset (spreadsheets, scanned data forms, scanned field notes, significant email correspondence, etc.) are archived in the MTNHP digital files, assigned Biotics Source Codes, and referenced in Vitalis, MTNHP's digital library catalog. Photographs with their auto-populated files names are archived in ThumbsPlus, MTNHP's photographic database. The final report was posted on the MTNHP website and cataloged on WorldCat. The report is assigned a Biotics Source Code and referenced in Vitalis.

2.5.2 Temperature Loggers

Data from each temperature logger was summarized using biological parameters thought to be important for pond drying and Water Howellia growth. The 24-hour period was partitioned into 'day' and 'night' hours. Sunrise and sunset times were selected from the Solar Calculator developed by the National Oceanic Atmospheric Administration (NOAA)⁷. Sunrise and sunset times were determined based on the mid-point of each month. The mid-month time was rounded to the nearest 15-minute increment and applied to all days of the particular calendar month. Ambient temperature was charted from May 10th to November 16th by calculating the averages for the day-length, night-length, and 24 hour-periods. The minimum and maximum temperatures in a 24-hour period were also charted.

⁷ NOAA Solar Calculator: <https://gml.noaa.gov/grad/solcalc/>. Accessed from November 12-15, 2024.

3.0 RESULTS AND DISCUSSION

The PDM protocol was implemented in 2022 and 2023 at 54 Water Howellia SOs (**Table 1; Figures A1-A6 in Appendix B**). These 54 Water Howellia SOs represent the two-year baseline dataset from which future monitoring results will be compared. Of the 54 Water Howellia SOs, 4 are “additional” that were not randomly selected⁸, 30 are the “primary” stratified random sample that must be monitored, and 20 are the “secondary” stratified random sample that should be monitored to improve statistical power in detecting a trend (**Table 1; Figures A1-A6 in Appendix B**). It is imperative for statistical reasons that only the stratified random sample of 50 ponds be used to detect a population trend at the end of the 15-year monitoring span. Thus, data is statistically summarized separately for the PDM SO and Additional SO datasets.

The PDM protocol as implemented in Montana, was an effective and efficient means to gather current data on Water Howellia populations, pond hydrology, and habitat conditions. The professional monitoring crew was trained, accessed sites, and collected monitoring data at 50 Water Howellia ponds in 2.5 to 3.5 days in each summer and autumn sessions. This timeframe also included travel time from their base station to the Condon Work Center. The summer monitoring session took a little longer to conduct than the autumn monitoring session, simply because searching for Water Howellia in a full pond takes more effort. Depending upon weather and site conditions, some of the 50 ponds may not be revisited in the autumn session (see PDM Plan 2020). During the monitoring period, crew members shared tidbits of information and tactics on how best to access occurrences. These helpful hints were compiled, and if used in future monitoring years will save on travel time; they are archived in the MTNHP project files (MTNHP 2023).

The stratified random sample of 50 Water Howellia SOs is a representative dataset for the 221 known occurrences documented from 1978 to 2022 (**Table 1**). Summer and autumn monitoring subsampled ponds in all geographical portions of its state range: north, east, west, and south (**Table 1**). Within the 4 geographical zones, all combinations of disturbance and previously monitored were subsampled (**Table 1**). Water Howellia SOs with undisturbed and disturbed 300-foot buffers were monitored. Past disturbances included the presence of at least one forest stand treatment, road, fire, or grazing activity occurring between 1978 and 2014 (see Pipp 2017). Water Howellia SOs that were part of a previous monitoring effort or not were subsampled. For previously monitored ponds, the PDM is adding to these long-term efforts. A future project should use this information to provide more insights into the plant’s biology and interactions with its environment.

⁸ Four ponds were purposely selected for easy access to train professionals and teach students the PDM protocol.

Table 1. The 54 Water *Howellia* SOs monitored from 2022 to 2023 with information on their PDM category, ownership, strata, and other metrics.

PDM Category ¹	MTNHP SO-ID ²	MTNHP SO-NUM ³	Location	Pond Size (acre)	Pond Ownership	Randomly Selected Strata ⁴	Disturbance Type(s) In 300-foot Buffer	Zone	Past Monitoring Dataset(s) ⁵ (years)
Primary	5000018	18	Dog Creek	0.98	Federal	Disturb, Monit, E	Stand Treatment, Road	E	USFS 1998-2007
Primary	5000023	23	Condon Creek	0.38	Federal	Disturb, Monit, E	Stand Treatment, Road	E	USFS 1998-2007
Primary	5000026	26	Condon Creek	0.45	Federal	Disturb, Monit, E	Stand Treatment, Road	E	USFS 1998-2007
Primary	5000184	184	Simpson Creek	0.64	Federal	Disturb, Monit, E	Stand Treatment, Road	E	TNC 2010-2012
Primary	5000108	108	U-024 pond in Cilly Creek Cluster	2.03	Federal	Disturb, Monit, N	Road	N	USFS 1998-2007
Primary	5000111	111	Pond U-53	0.25	Federal	Disturb, Monit, S	Road	S	USFS 1998-2007
Primary	5000188	188	Windfall Creek	0.26	Federal	Disturb, Monit, S	Road	S	TNC 2010-2012
Primary	5000047	47	Lindbergh Lake	0.68	Federal	Disturb, Monit, S	Road, Grazing	S	USFS 1998-2007
Primary	5000126	126	North of Cygnet Lake (Cushman Pond #9)	0.21	Federal	Disturb, Monit, S	Stand Treatment	S	TNC 2010-2012
Primary	5000146	146	Stoner Lake	2.37	Federal	Disturb, Monit, S	Stand Treatment	S	TNC 2010-2012
Primary	5000147	147	Stoner Lake	0.82	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Primary	5000176	176	FR 9772	0.64	Federal	Disturb, Monit, S	Stand Treatment, Fire	S	TNC 2010-2012
Primary	5000065	65	Stoner Lake Pothole #8	2.34	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Primary	5000123	123	North of Cygnet Lake (Cushman Pond #6)	0.43	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Primary	5000164	164	HWY 83-Holland Creek	1.23	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Primary	5000093	93	Piper Creek Pond #4	0.15	Federal	Disturb, Monit, W	Road	W	USFS 1998-2007; Other
Primary	5000060	60	Shay Lake Pothole	0.93	Federal	Disturb, Monit, W	Stand Treatment	W	TNC 2010-2012
Primary	5000143	143	Condon Creek	0.35	Federal	Disturb, notMonit, E	Stand Treatment, Road	E	
Primary	5000216	216	Cilly Creek	0.31	State	Disturb, notMonit, N	Road	N	
Primary	5000036	36	Lindbergh Lake	0.32	Federal	Disturb, notMonit, S	Road	S	
Primary	5000138	138	Glacier Creek	0.2	Federal	Disturb, notMonit, S	Stand Treatment, Fire	S	
Primary	5000165	165	HWY 83-Holland Creek	0.17	Federal	Disturb, notMonit, S	Stand Treatment, Road	S	
Primary	5000178	178	HWY 83-Holland Creek	0.05	State	Disturb, notMonit, S	Stand Treatment, Road	S	
Primary	5000195	195	Glacier Creek	0.07	State	Disturb, notMonit, S	Stand Treatment, Road	S	
Primary	5000162	162	Pierce Creek	2.91	Federal	Disturb, notMonit, S		S	

Table 1 (continued). The 54 Water *Howellia* SOs monitored from 2022 to 2023 with information on their PDM category, ownership, strata, and other metrics.

PDM Category ¹	MTNHP SO-ID ²	MTNHP SO-NUM ³	Location	Pond Size (acre)	Pond Ownership	Randomly Selected Strata ⁴	Disturbance Type(s) In 300-foot Buffer	Zone ⁴	Past Monitoring Dataset(s) ⁵ (years)
Primary	5000172	172	FR 9773	0.44	Federal	Disturb, notMonit, S		S	
Primary	5000008	8	Lost Creek Bench	0.44	Federal	noDisturb, Monit, N		N	USFS 1988-1997; USFS 1998-2007
Primary	5000074	74	Holland Lake Pond #3	0.43	Federal	noDisturb, Monit, S		S	USFS 1998-2007
Primary	5000215	215	Cilly Creek	0.18	Federal	noDisturb, notMonit, N		N	
Primary	5000211	211	Cedar Creek	1.13	Federal	noDisturb, notMonit, W		W	
Secondary	5000027	27	Condon Creek	0.87	Federal	Disturb, Monit, E	Stand Treatment	E	USFS 1988-1997; USFS 1998-2007
Secondary	5000135	135	Falls Creek	0.07	Federal	Disturb, Monit, E	Stand Treatment, Road	E	TNC 2010-2012; Other
Secondary	5000130	130	Road 10161 Pond, (Transplant Pond A), U-010	0.55	Federal	Disturb, Monit, N	Road	N	Other
Secondary	5000173	173	FR 9772	0.25	Federal	Disturb, Monit, S	Stand Treatment, Fire	S	TNC 2010-2012
Secondary	5000038	38	Lindbergh Lake	1.29	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012; Other
Secondary	5000069	69	Stoner Lake Pothole #21	0.89	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Secondary	5000186	186	Pond north of Cygnet Lake	0.54	Federal	Disturb, Monit, S	Stand Treatment, Road	S	TNC 2010-2012
Secondary	5000086	86	Elk Creek Pond 1-1	0.32	State	Disturb, Monit, S		S	USFS 1998-2007
Secondary	5000190	190	Shay Lake	0.18	Federal	Disturb, Monit, W	Stand Treatment, Road	W	TNC 2010-2012
Secondary	5000086	86	Elk Creek Pond 1-1	0.32	State	Disturb, Monit, S		S	USFS 1998-2007
Secondary	5000190	190	Shay Lake	0.18	Federal	Disturb, Monit, W	Stand Treatment, Road	W	TNC 2010-2012
Secondary	5000129	129	North of Cygnet Lake	0.8	State	Disturb, notMonit, S	Road	S	
Secondary	5000191	191	Kraft Creek Road	0.31	State	Disturb, notMonit, S	Road	S	
Secondary	5000179	179	Holland Lake	0.3	Federal	Disturb, notMonit, S	Stand Treatment	S	
Secondary	5000137	137	Glacier Creek	0.1	Federal	Disturb, notMonit, S	Stand Treatment, Fire, Road	S	
Secondary	5000209	209	Cedar Creek	1.09	Federal	Disturb, notMonit, W	Stand Treatment, Road	W	
Secondary	5000015	15	Lost Creek-Cilly Creek Ponds	0.28	Federal	noDisturb, Monit, N		N	USFS 1998-2007

Table 1 (continued). The 54 Water *Howellia* SOs monitored from 2022 to 2023 with information on their PDM category, ownership, strata, and other metrics.

PDM Category ¹	MTNHP SO-ID ²	MTNHP SO-NUM ³	Location	Pond Size (acre)	Pond Ownership	Randomly Selected Strata ⁴	Disturbance Type(s) In 300-foot Buffer	Zone	Past Monitoring Dataset(s) ⁵ (years)
Secondary	5000005	5	Swan River Oxbow-Subpop 1	2.31	TNC	noDisturb, notMonit, N		N	
Secondary	5000078	78	Barber Creek	0.38	Federal	noDisturb, Monit, S		S	USFS 1998-2007
Secondary	5000160	160	Piper Creek	0.37	Federal	noDisturb, Monit, W		W	TNC 2010-2012
Secondary	5000155	155	Dog Creek	1.71	Federal	noDisturb, notMonit, E		E	
Secondary	5000134	134	Swan River Oxbow-Subpop 4	0.31	TNC	noDisturb, notMonit, N		N	
Additional	5000019	19	Dog Creek	1.63	Federal	not applicable	Stand Treatment	E	USFS 1998-2007
Additional	5000140	140	Condon Creek, U-076	1.04	Federal	not applicable	Stand Treatment	E	Other
Additional	5000157	157	Condon Creek	0.87	Federal	not applicable	Stand Treatment	E	
Additional	5000044	44	Lindbergh Lake	0.23	Federal	not applicable		S	USFS 1998-2007

¹ Priority for monitoring in Years 7-8 and 14-15. Primary = the stratified random sample of the 30 SO minimum that must be monitored. Secondary = the stratified random sample of 20 SOs that should be monitored. Additional = 4 SOs that could be monitored but are not randomly selected.

² SO-ID is a unique identifier for the Species Occurrence in the state.

³ SO-NUM is an identifier for the occurrence relative to the species.

⁴ Strata for the SO-ID:

- The 300-foot forest buffer has a known (“Disturb”) or no known (“noDisturb”) disturbance; see Disturbance Type.
- The pond is part of a previous monitoring study (“Monit”) or has not been monitored (“notMonit”); see Past Monitoring Dataset(s).
- Geographical zone within the statewide range for *Howellia aquatilis*: N = north, E = east; S = south, W = west.

⁵ Previous monitoring studies: US Forest Service 1988-1997 and 1998-2007; The Nature Conservancy (TNC) 2010-2012; Other are SOs predominantly monitored by the MTNHP.

Bolded rows are Water *Howellia* SOs where iButtons were installed to record ambient air temperature in 2023.

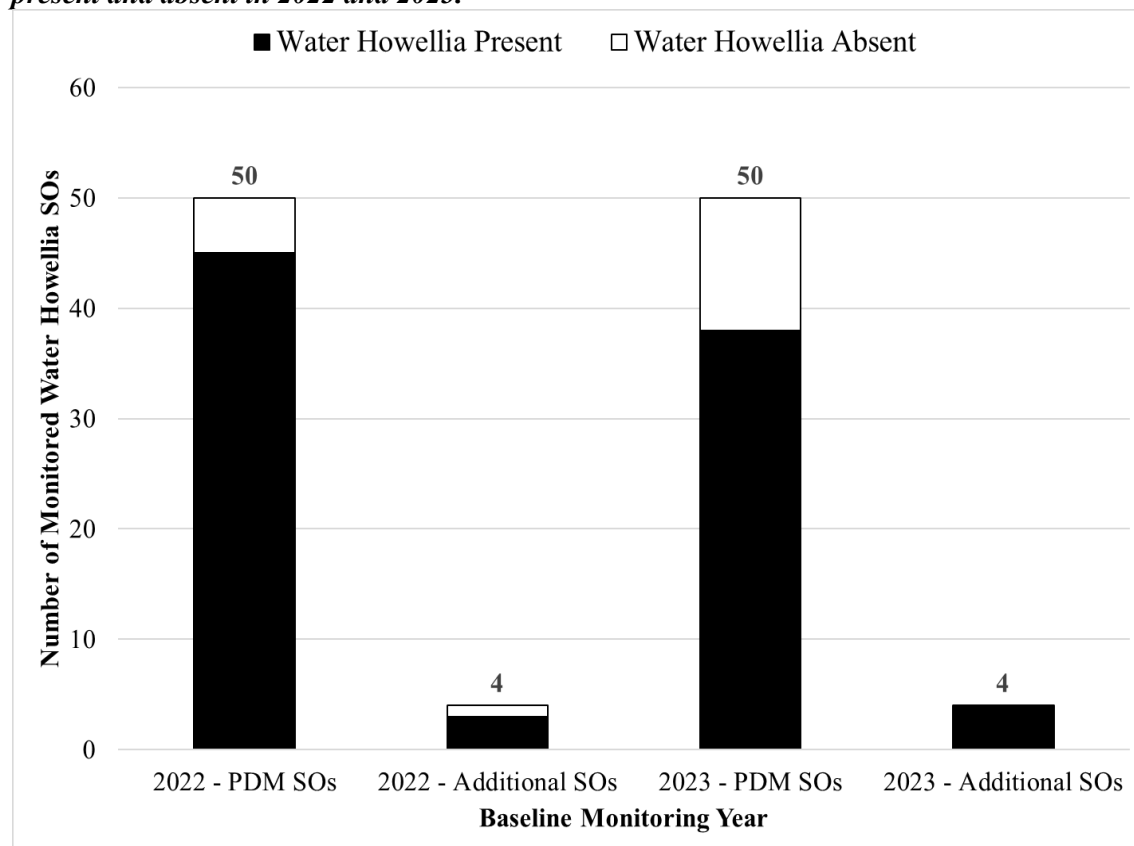
3.1 Summer Monitoring Session

The summer monitoring session evaluated many elements of Water Howellia ponds and their 300-foot buffers. These elements included: pond hydrology; Water Howellia and Reed Canarygrass presence, abundance, and distribution; submergent and emergent vegetation; invasive and noxious weed presence; and threats to the plants, water, and habitat of the ponds. Pond hydrology is discussed under the *Autumn Monitoring Session* section of this report.

3.1.1 Water Howellia – *Howellia aquatilis*

The same 54 Water Howellia ponds were monitored consecutively in July of 2022 and 2023. For the 50 PDM SOs, Water Howellia plants were present at 45 ponds in 2022 and at 38 ponds in 2023 (**Figure 4**). For the 4 additional Water Howellia SOs, plants were present at 3 ponds in 2022, and all ponds in 2023 (**Figure 4**). Although Water Howellia was found in the majority of monitored SOs, presence at PDM sites declined between 2022 to 2023. This decline reflects the search effort noted by crew members in 2023. Field crews uniformly experienced difficulties in finding Water Howellia plants in 2023, which was not the case in 2022. Plant and flower size also seemed to be smaller or spindlier. In July 2022 crews found high water conditions coupled with high temperatures for SOs – factors that can aid growth for Water Howellia. The winter of 2022 to 2023 resulted in a lean snowpack. In July of 2023, crews found lower water levels, and some dry ponds, in July of 2023. Unfortunately, the lack of complete and comprehensive temperature and precipitation data prevents us from properly assessing these environmental conditions relative to Water Howellia abundances in 2023 (see *Section 3.3 Ambient Temperature Monitoring*).

Figure 4. The number of monitored Water Howellia Species Occurrences (SOs) where the plant was present and absent in 2022 and 2023.

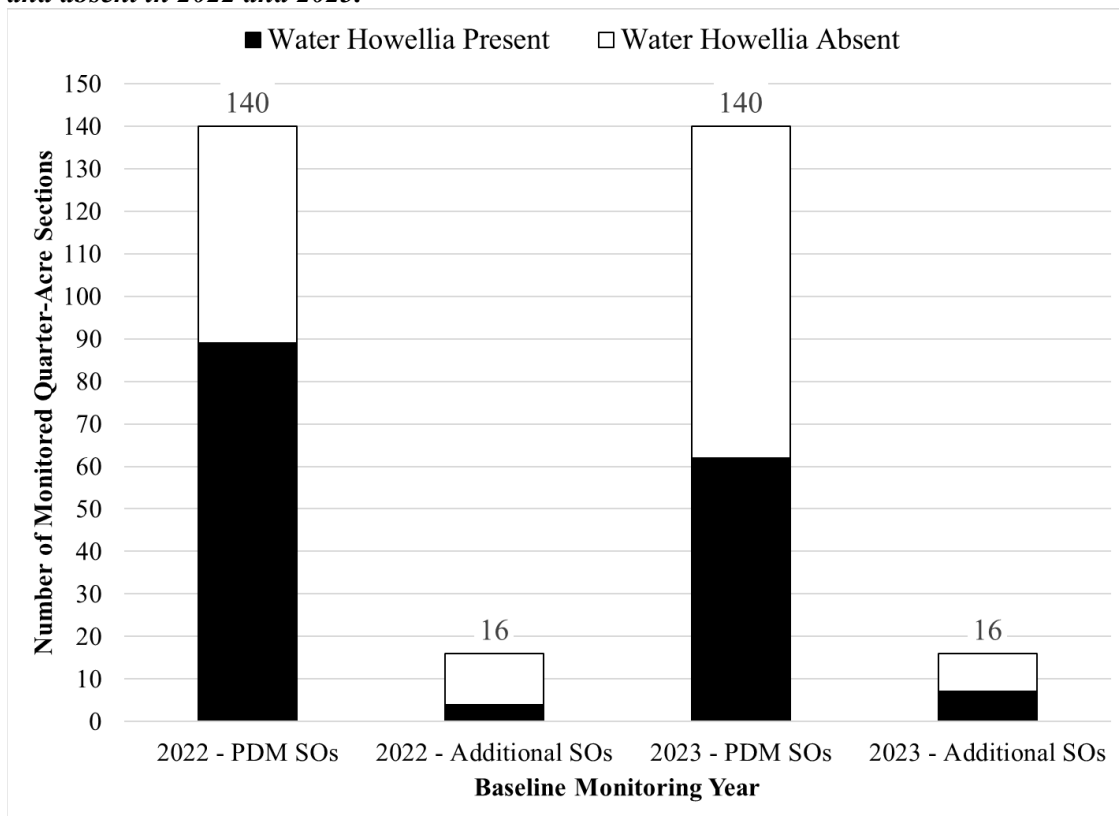


The presence of Water Howellia at SO 130 has a unique history. In the 1980s this pond was determined by USFS botanists to be unoccupied, potential habitat for Water Howellia (Shelly 1998). It was one of

four ponds selected for a translocation experiment. In September 1989 fifteen soils plugs were taken from two dense donor populations at other ponds and planted into SO 130 at specific points along a transect. In 1990 32 flowering (submergent and emergent), fruiting, and vegetative Water Howellia plants were found. In 1991 4 flowering (submergent and emergent) plants were found. Plants were found absent in 1998 through 2000, present in 2001 and 2007, and absent in 2012, 2022, and 2023. Readers who want more details or are interested in the ethics of translocation and reintroduction of plants should consult the *Forum on Research and Management of Howellia aquatilis* (Turnbill National Wildlife Refuge 1998).

Water Howellia plants are not evenly distributed within a pond or old river oxbow. As previously addressed under methods, the pond is not a suitable sample unit for statistically analyzing Water Howellia distributions and population abundances. Hence, each pond is divided into quarter-acre sections which become the sampling unit for statistically analyzing PDM data. The 50 PDM and 4 additional ponds consist of 140 and 16 quarter-acre sections, respectively. In 2022 Water Howellia plants were found in 89 of 140 PDM quarter-acre sections – 64% occupancy (**Figure 5**). In 2023 plants were found in 62 PDM quarter-acre sections – 44% occupancy (**Figure 5**). This indicates that Water Howellia presence declined from 2022 to 2023 at PDM ponds. At the additional SOs, Water Howellia was found in 4 and 7 of 16 quarter-acre sections, respectively for 2022 and 2023; this equated to a 25% and 44% occupancy rate in 2022 and 2023 respectively. Knowing that populations naturally fluctuate, a statistical test of significance was not done; rather this will be analyzed against the future two-consecutive year monitoring periods.

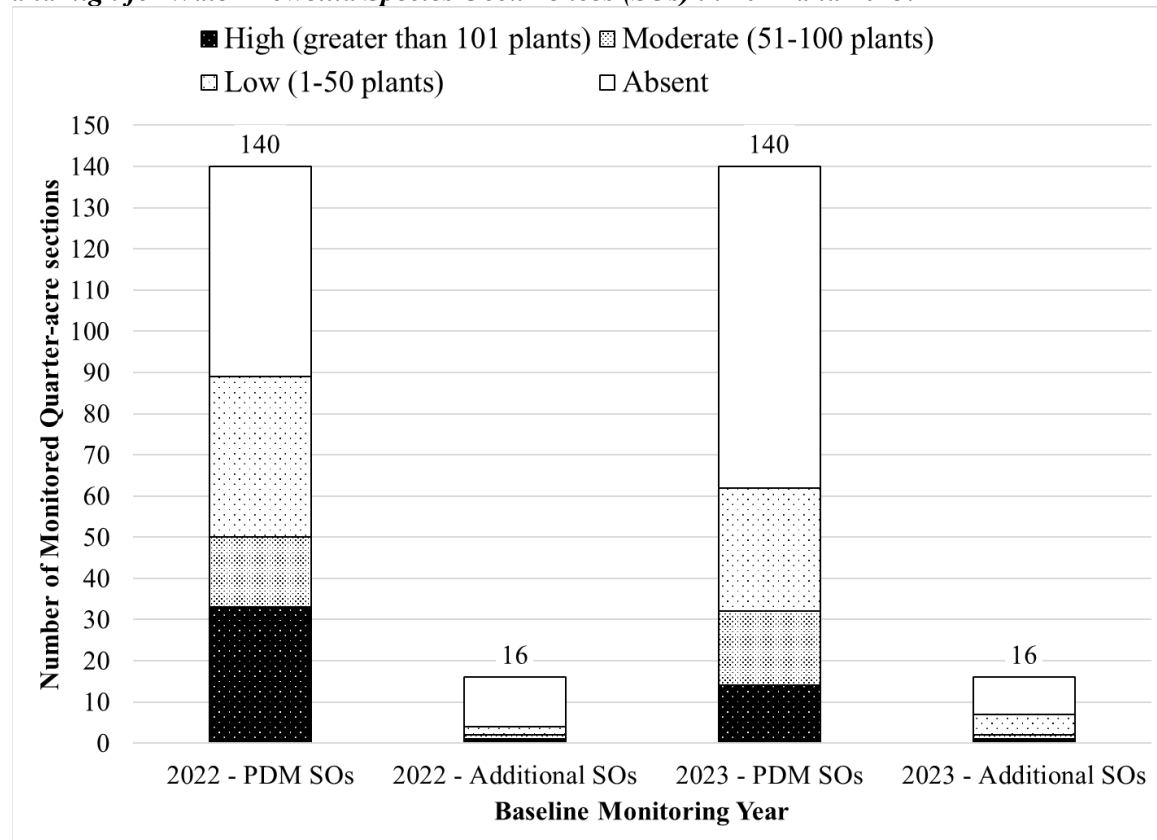
Figure 5. The number of monitored quarter-acre sections where Water Howellia plants were present and absent in 2022 and 2023.



Within each quarter-acre section, the abundance of Water Howellia plants was quantified with categorical ratings of absent, low, moderate, and high (**Figure 6**). In 2022, crews counted 33 high- and 39-low abundance ratings for quarter-acre sections. In 2023, the number of quarter-acre sections with high and low abundances dropped to 14 and 30, respectively. The number of quarter-acre sections with a moderate

abundance rose by one from 17 in 2022 to 18 in 2023. The number of quarter-acre sections where Water Howellia was absent rose from 51 in 2022 to 78 in 2023. For the 4 additional SOs, abundance ratings were stable or increased from 2022 to 2023. The number of high, moderate, and low abundance rated quarter-acre sections went from 2, 1, and 1 in 2022 to 5, 1, and 1 in 2023, respectively. The 12 quarter-acre sections in 2022 where Water Howellia was absent declined to 9 sections in 2023.

Figure 6. The number of quarter-acre sections assigned to abundance ratings of absent, low, moderate, and high for Water Howellia Species Occurrences (SOs) in 2022 and 2023.



Reed Canarygrass - *Phalaris arundinacea*

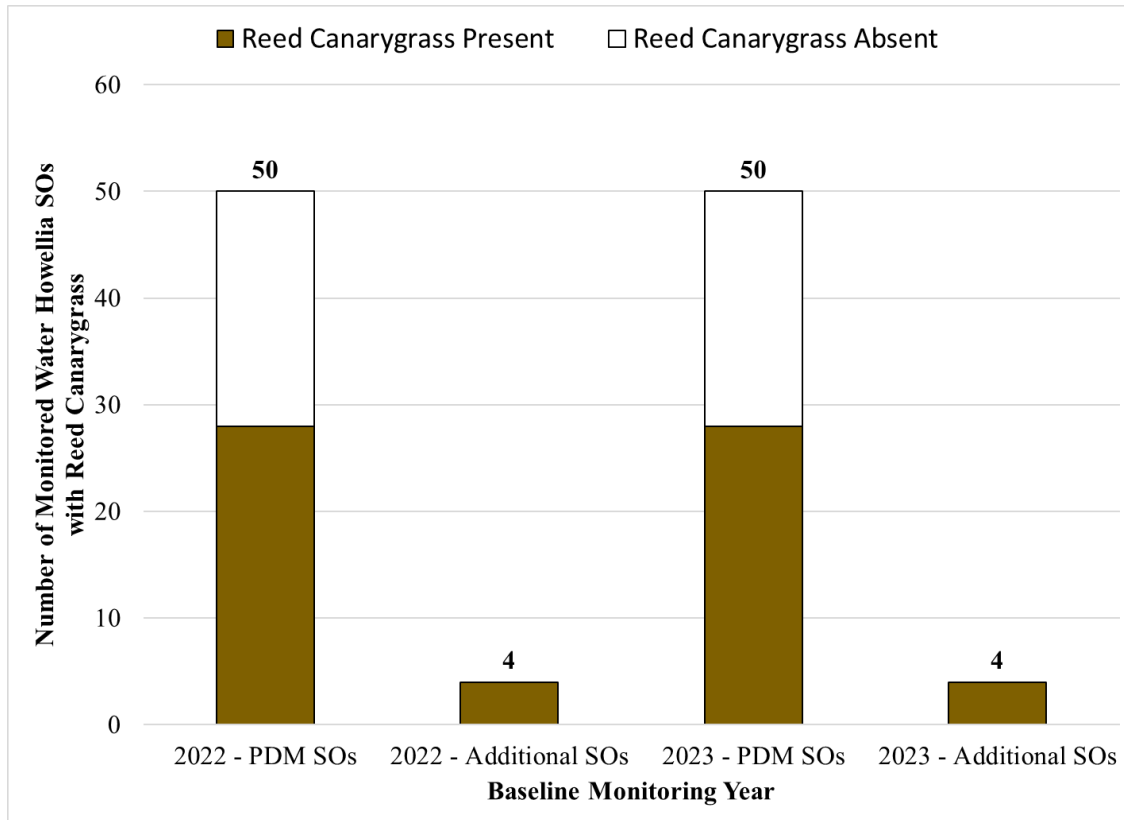
In the final listing rule, invasive plant species and specifically Reed Canarygrass and Yellow Flag Iris (*Iris pseudacorus*), were identified to have the capacity to outcompete Water Howellia for nutrients and space (59 FR 35860-Federal Register 1994; Lesica 1997; Clegg et al. 2000; Lichthardt and Pekas 2017). Reed Canarygrass has a long history of being present at some Water Howellia ponds and old river oxbows. Previous monitoring studies in Montana collected data on Reed Canarygrass to determine if plants are expanding and threatening Water Howellia populations. Previous monitoring has not detected a trend though more monitoring data and further studies into the ecology and genetics of Reed Canarygrass are needed.

Reed Canarygrass has a circumglobal distribution in the northern hemisphere (Casler et al. 2009). Native populations and non-native cultivars of Reed Canarygrass occur in Montana. The Lewis and Clark expedition of 1804-1806 collected Reed Canarygrass in Montana as did many other pioneering botanists from 1825 to 1911 (Lesica et al. 2022; Merigliano and Lesica 1998). Reed Canarygrass also has a long agronomic history of cultivation that began in 1749 in Sweden (Merigliano and Lesica 1998). Experiments to grow strains that were more palatable than the wild strain began with trials in England (1812), Germany (1836), and the United States (mid-1930s) (Merigliano and Lesica 1998). The expansion

of Reed Canarygrass across many habitats in the US, including Montana, combined with uncertain origins and the confirmation of an invasive hybrid of *Phragmites* has led to the hypothesis that European x native hybrids are more aggressive than native populations (Saltonstall 2002; Casler et al. 2009). To date the hypothesis of native strains and aggressive exotic strains has not been conclusively demonstrated nor have genotypes been differentiated with morphological characteristics. Given the presence of native and exotic strains of Reed Canarygrass in Montana, the PDM continues to gather data on this grass at Water Howellia SOs.

The presence of Reed Canarygrass was observed at the same 54 Water Howellia SOs in 2022 and 2023. Of the 50 PDM SOs, Reed Canarygrass was present at 28 (56%) and absent at 22 ponds in 2022 (**Figure 7**). Reed Canarygrass was found at all 4 additional SOs in 2022 (**Figure 7**). In 2023, the presence or absence of this grass in the 54 monitored ponds remained the same – a statistic that makes sense for a perennial grass (**Figure 7**).

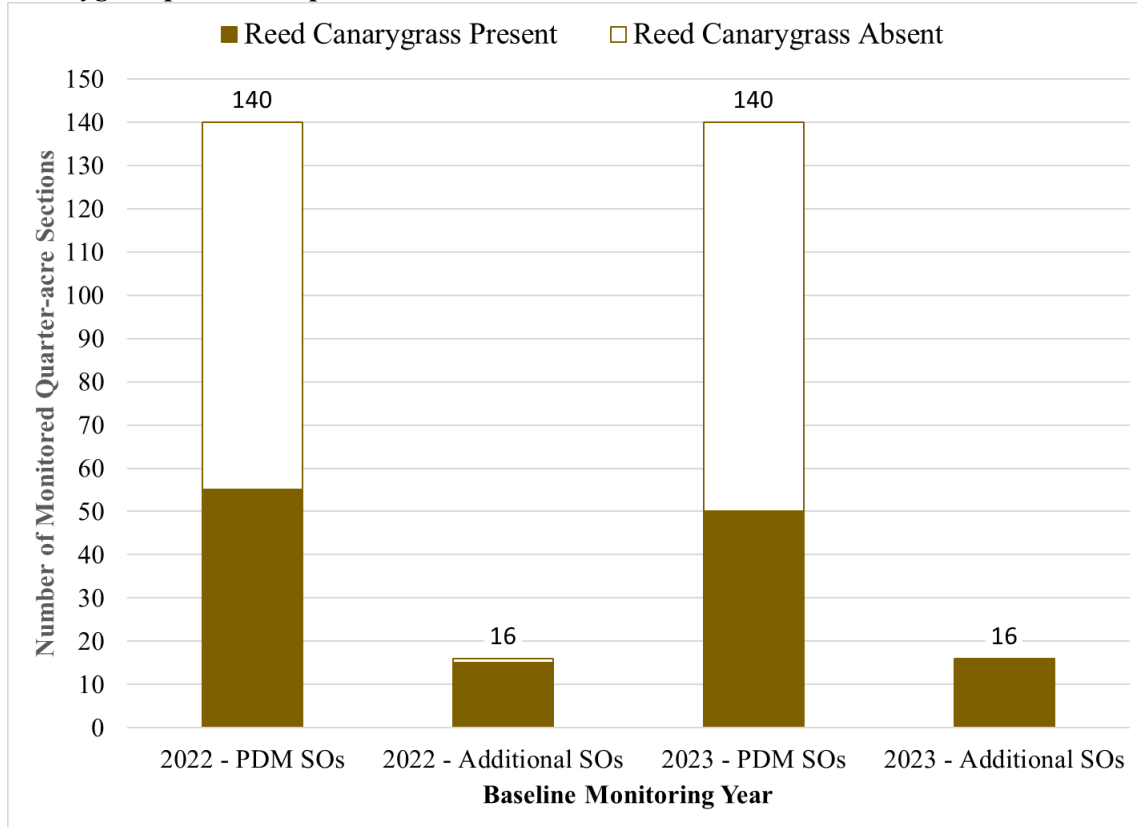
Figure 7. The number of monitored Water Howellia SOs where Reed Canarygrass plants were present and absent in 2022 and 2023.



The presence of Reed Canarygrass was collected at the quarter-acre sampling units in 2022 and 2023. For Water Howellia PDM SOs, the number of quarter-acre sections with Reed Canarygrass dropped slightly from 50 to 55 between 2022 and 2023 (**Figure 8**). Conversely, the number of quarter-acre sections without Reed Canarygrass increased from 85 to 90 between 2022 and 2023, respectively (**Figure 8**). For the additional Water Howellia SOs the presence of Reed Canarygrass increased slightly from 15 to 16 quarter-acre sections between 2022 and 2023, respectively (**Figure 8**). This was matched by an assigned absence of Reed Canary grass at a single quarter acre-section between 2022 and 2023, respectively (**Figure 8**). Although Reed Canarygrass is perennial, several factors can affect its detection at the quarter-acre scale. These factors are relative to the growth of Reed Canarygrass and include water

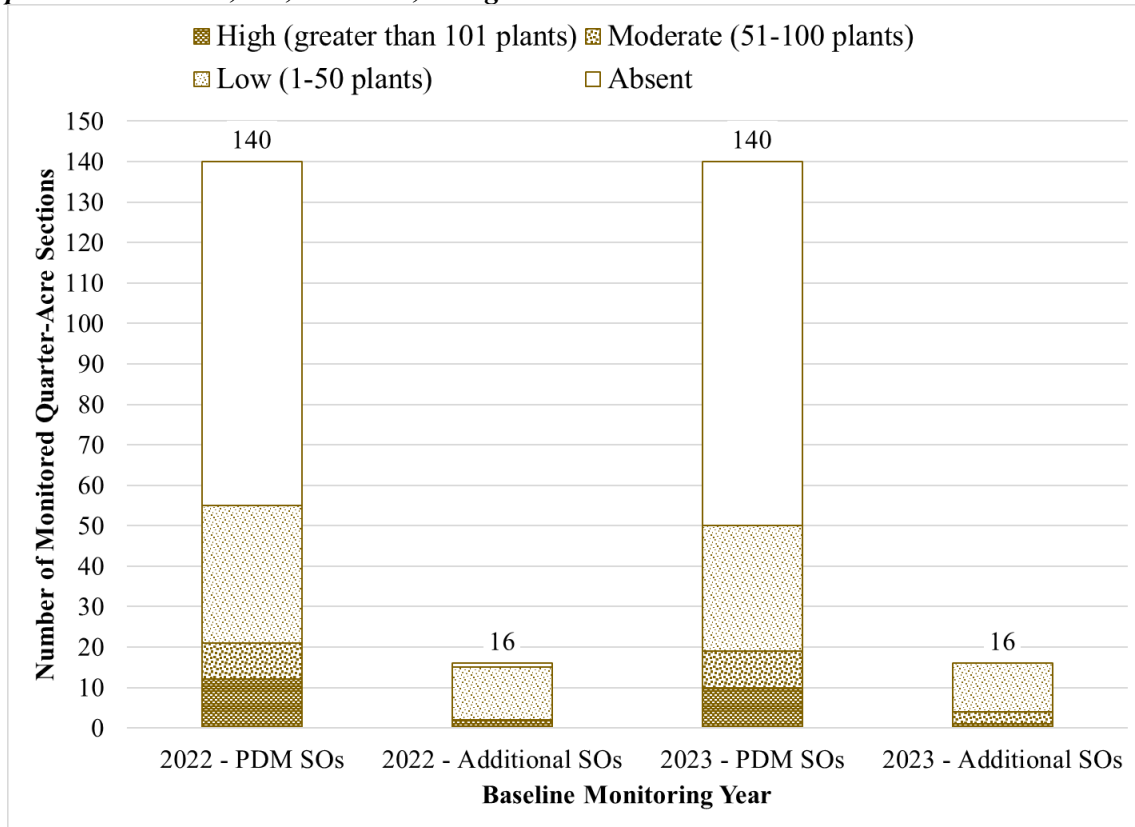
depth, height and density of associated vegetation, survey effort by the observer, and other conditions that can kill this grass. Knowing that all plant species populations naturally change through time, a statistical test of significance was not done; rather this will be analyzed against the future two-consecutive year monitoring periods.

Figure 8. The number of monitored quarter-acre sections within Water Howellia SOs where Reed Canarygrass plants were present and absent in 2022 and 2023.



Within each quarter-acre section of the monitored Water Howellia SOs, the abundance of Reed Canarygrass was quantified with categorical ratings of absent, low, moderate, and high (**Figure 9**). Of the 140 quarter-acre sections, 12-high, 9-moderate and 34-low abundance sections were recorded for Reed Canarygrass in 2022. These numbers dropped slightly to 10-high and 31-low and remained steady for the 9-moderate rated quarter-acre sections in 2023. Conversely, the number of quarter-acre sections without Reed Canarygrass rose from 85 in 2022 to 90 in 2023. The apparent decline of Reed Canarygrass at some quarter-acre sections is unknown. In general, Water Howellia SOs were drier in 2023 than in 2022, which influences the dynamics (growth, numbers, and composition) among species within these biologically diverse ponds. Associated vegetation, water depth, survey effort, and conditions that cause death for Reed Canarygrass can influence the reported categorical abundance.

Figure 9. The number of quarter-acre sections within Water Howellia SOs where Reed Canarygrass plants were absent, low, moderate, or high in 2022 and 2023.



3.1.3 Emergent and Submergent Vegetation

Numerous vascular plant and animal species co-occur with Water Howellia plants below and above the water's surface, whether or not the vernal pond is full, drying, or dry. Water Howellia roots in the pond's floor (bottom), grows leafy, often long stems, and flowers and fruits both below and above the water's surface. The PDM protocol in Montana collects data on the total abundance of submergent and emergent vascular plants because they have the potential to compete and/or promote the germination, growth, reproduction, and viability of Water Howellia. It was determined ignoring submergent and emergent vascular plants could lead to an important loss of information relative to changes in plant populations and pond ecology through the 15-year monitoring span.

For all monitored Water Howellia SOs, submergent, emergent, or both vegetation types were present with varying values of cover (**Table 2**). The cover values recorded in 2022 and 2023 for a given Water Howellia SO cannot be compared because the methods changed (see Section 2.0 *Methods*). However, it is deduced that submergent and/or emergent cover present in 2022 was also present in 2023, but dependent upon the pond's hydrology. Where surface water was not present in July, submergent vegetation should have been recorded as none or not applicable (na); however, methods in 2023 were still evolving. With this report the methods have been refined and data collection at the quarter-acre section level should make this information more repeatable and useful through the 15-year monitoring window.

Table 2. Submergent and Emergent vegetation cover at the 50 PDM Water *Howellia* and 4 additional* Species Occurrences (SOs).

Water <i>Howellia</i> SO	Vegetation Type	2022 ESTIMATED POND Percent Cover by Vegetation Type	2023 Percent Cover Category by Section and Vegetation Type ¹										
			S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
5	Emergent	85	H	H	H	H	H	H	H	H			
	Submergent	5	na	na	na	na	na	na	na	na			
8	Emergent	75	M	M									
	Submergent	10	L	L									
15	Emergent	35	H										
	Submergent	35	M										
18	Emergent	90	VH	VH	VH								
	Submergent	50	VH	VH	VH								
19*	Emergent	90	VH										
	Submergent	90	VH										
23	Emergent	15	M										
	Submergent	20	VH										
26	Emergent	100	VH	VH									
	Submergent	35	L	L									
27	Emergent	100	VH	VH	VH								
	Submergent	5	L	L	L								
36	Emergent	80	H										
	Submergent	80	VH										
38	Emergent	50	M	M	M	M	M						
	Submergent	60	H	H	VH	H	H						
44*	Emergent	35	M	H									
	Submergent	50	L	M									
47	Emergent	90	VH	VH	H								
	Submergent	80	H	H	H								
60	Emergent	75	VH	M	M	M	VH						
	Submergent	30	VH	H	H	H	VH						
65	Emergent	45	H	H	H	H	H	VH	VH	VH			
	Submergent	27	VH	VH	VH	VH	VH	VH	VH	VH			
69	Emergent	20	L	L	L	L	L						
	Submergent	10	L	L	L	L	L						
74	Emergent	98	VH	VH									
	Submergent	10	VH	VH									
78	Emergent	80	H	H									
	Submergent	80	H	H									
86	Emergent	10	L	L									
	Submergent	45	L	L									
93	Emergent	60	H										
	Submergent	25	VH										

Table 2 (continued). Submergent and Emergent vegetation cover at the 50 PDM Water *Howellia* Species Occurrences (SOs) and 4 additional* SOs.

Water <i>Howellia</i> SO	Vegetation Type	2022 ESTIMATED POND Percent Cover by Vegetation Type	2023 Percent Cover Category by Section and Vegetation Type ¹										
			S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
108	Emergent	80	VH	VH	VH	VH	VH	VH	VH	VH			
	Submergent	5	L	L	L	L	L	L	L	L			
111	Emergent	95	VH										
	Submergent	10	L										
123	Emergent	25	H	M									
	Submergent	45	VH	M									
126	Emergent	35	H										
	Submergent	40	VH										
129	Emergent	40	VH	H	H								
	Submergent	60	N	N	N								
130	Emergent	55	M	M									
	Submergent	10	L	L									
134	Emergent	90	VH										
	Submergent	10	L										
135	Emergent	70	VH	VH									
	Submergent	5	N	N									
137	Emergent	70	M										
	Submergent	95	H										
138	Emergent	85	VH										
	Submergent	75	N										
140*	Emergent	90	VH	VH	VH	VH							
	Submergent	95	H	H	H	H							
143	Emergent	95	H										
	Submergent	25	H										
146	Emergent	40	H	H	H	H	H	H	H	H			
	Submergent	25	H	H	H	H	H	H	H	H			
147	Emergent	40	M	M	M								
	Submergent	10	M	M	M								
155	Emergent	95	VH	VH	VH	VH	VH	VH	VH				
	Submergent	20	VH	VH	VH	VH	VH	VH	VH				
157*	Emergent	95	VH	H	VH	VH							
	Submergent	95	L	L	L	L							
160	Emergent	75	VH	M									
	Submergent	50	VH	H									
162	Emergent	65	H	H	H	H	H	H	H	H	H	H	H
	Submergent	60	L	L	L	L	L	L	M	M	M	L	L
164	Emergent	90	VH	VH	VH	VH							
	Submergent	5	H	H	H	H							
165	Emergent	85	VH										
	Submergent	?	H										

Table 2 (continued). Submergent and Emergent vegetation cover at the 50 PDM Water *Howellia* Species Occurrences (SOs) and 4 additional* SOs.

Water <i>Howellia</i> SO	Vegetation Type	2022 ESTIMATED POND Percent Cover by Vegetation Type	2023 Percent Cover Category by Section and Vegetation Type ¹										
			S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
172	Emergent	90	M	M									
	Submergent	95	M	H									
173	Emergent	70	H										
	Submergent	80	VH										
176	Emergent	65	L	L	M								
	Submergent	35	M	L	M								
178	Emergent	17	L										
	Submergent		L										
179	Emergent	15	L										
	Submergent	10	L										
184	Emergent	40	M	M	H								
	Submergent	35	L	M	M								
186	Emergent	80	H	H									
	Submergent	60	L	L									
188	Emergent	5	L										
	Submergent	85	L										
190	Emergent	20	L										
	Submergent	30	M										
191	Emergent	90	VH										
	Submergent	10	VH										
195	Emergent	90	H										
	Submergent	20	VH										
209	Emergent	70	H	H	H	H							
	Submergent	60	H	H	H	H							
211	Emergent	90	H	VH	VH	VH							
	Submergent	60	VH	VH	VH	VH							
215	Emergent	40	L										
	Submergent	40	L										
216	Emergent	70	M										
	Submergent	20	L										

¹ VH = Very High, 76-100% cover

H = High, 51-75% cover

M = Moderate, 26-50% cover

L = Low, 1-25% cover

N = None, 0% cover

NA = not applicable, usually because the SO lacks surface water.

3.1.4 Noxious Weeds

In general, noxious and invasive plant species threaten Water Howellia populations and vernal pond ecology. This is predominantly because noxious and invasive plant species are not native to Montana and lack vectors that control their populations. The PDM protocol in Montana includes surveying for and recording the presence or absence of State of Montana and agency-level noxious and invasive vascular plants that occur in the vernal pool and adjacent habitat. Surveying for invasive and noxious weeds is part of the summer and autumn monitoring protocols.

Noxious weeds and other non-native plants were documented at seven PDM and no Additional Water Howellia SOs in 2022 and 2023 (**Table 3**). Noxious weeds were not found at the four additional Water Howellia SOs. Ox-eye Daisy (*Leucanthemum vulgare*) and Canada Thistle (*Cirsium arvense*) are designated as noxious in Montana and were found in, on the perimeter of, or in the upland buffer for five ponds (**Table 3**). Bull Thistle (*Cirsium vulgare*) which is an aggressive non-native plant, but not designated as noxious was found along one Water Howellia SO (**Table 3**). Roadside weeds were reported without details at one Water Howellia SO (**Table 3**).

Table 3. Noxious and other non-native plants found at 54 monitored Water Howellia SOs in 2022 and 2023.

Water Howellia SO	Non-Native Vascular Plants Common Name <i>Scientific Name</i>	State Designation	Comments
36	Ox-eye Daisy <i>Leucanthemum vulgare</i>	Noxious	Along road.
126	Canada Thistle <i>Cirsium arvense</i>	Noxious	
138	Bull Thistle <i>Cirsium vulgare</i>		Along east end of pond.
146	roadside weeds		Plenty and along the two-track road, north of pond.
162	Canada Thistle <i>Cirsium arvense</i>	Noxious	Near <i>Phalaris arundinacea</i> in Section 7.
165	Ox-eye Daisy <i>Leucanthemum vulgare</i>	Noxious	In highway right-of-way and adjacent to pond.
178	Ox-eye Daisy <i>Leucanthemum vulgare</i>	Noxious	In highway right-of-way and adjacent to pond.

In the final listing rule, invasive plant species and specifically Yellow Flag Iris (*Iris pseudacorus*), were identified to have the capacity to outcompete Water Howellia (Federal Register 1994). Since its listing in 1994, Yellow Flag Iris has colonized areas of northwest Montana. Yellow Flag Iris was not found at the 54 monitored ponds in 2022 and 2023, and is not known to occur in the Swan Valley (MTNHP 2024). However, Yellow Flag Iris has been documented north and south of the Swan Valley in vicinity of Whitefish, Kalispell, Hungry Horse, and Seeley Lake. The closest observation in vicinity of Seeley Lake were reported by Missoula County in 2006, 2015, and 2018. This project did not investigate if these noxious weed populations were or are under management control.

The two-year monitoring effort found, but did not document, the many dirt roads and right-of-ways where populations, some extensive, of Ox-eye daisy, Canada Thistle, Spotted Knapweed and other noxious weeds occur. What the two-year baseline did document was that 9% of the 54 monitored Water Howellia SOs have some level of Canada Thistle and Ox-eye Daisy. Control efforts, if warranted and implemented are not part of this monitoring. However, the next rounds of two-consecutive year monitoring efforts will track the expansion or decline of these and any other identified noxious or invasive species.

3.1.5 Livestock Grazing

In the final listing rule, habitat changes due to livestock grazing was as a threat (Federal Register 1994). The PDM protocol in Montana collected presence/absence data on livestock grazing at the 54 monitored Water Howellia SOs and their 300-foot buffers in both the summer and autumn monitoring sessions. Livestock grazing was not found at the 54 monitored Water Howellia SOs in 2022 and 2023. Cattle grazing will continue to be assessed through the 15-year monitoring window.

3.2 Autumn Monitoring Session

Pond hydrology data was recorded during both summer and autumn monitoring sessions. The summer session documented pond filling, degree of fullness, and water clarity. The autumn monitoring session focused on quantifying pond drying, invasive and noxious weed presence, and threats to the pond and its 300-foot buffer. Invasive and noxious weeds are discussed under the *Summer Monitoring Session* section of this report. The autumn monitoring visit determines if the pond's surface water drew down – and to what degree. In addition, the autumn session includes a casual search to find germinated seeds of Water Howellia. Finding germinated seeds is difficult, and in 2022 and 2023 the crews found none. This is assumed due to warm night- and/or day-time temperatures in October. Seeds need to go through a cold-stratification period to germinate (Lesica et al. 1990).

Montana's vernal ponds are seasonal depressional wetlands that occur in glaciated areas. In the Swan Valley of Montana⁹, they occur in forested valley bottoms and are classified as the Rocky Mountain Wooded Vernal Pool Ecological System¹⁰. Vernal pools are unique in that they fill with shallow water from winter's snowmelt and spring precipitation and draw down through the summer – at least in most years. They may be completely or partially dry for most of the summer and fall. Vernal ponds do not draw down uniformly because their vertical and horizontal profiles are typically asymmetrical. As discussed in the *Life Cycle* section of this report, Water Howellia plants rely on the annual fluctuations of pond filling and drying to complete their one-year life cycle.

3.2.1 2022 Pond Hydrology

In 2022 the PDM protocol for documenting pond filling and drying became problematic. The method uses a single transect to measure the extent of surface water and depth from the pond's edge to its center. At intervals along the transect water depth was measured; however, the pond's center was often not reachable and sometimes difficult to identify. This is because the size, shape, and vertical and horizontal profiles are drastically different among ponds. In years with high water, assessing water depth becomes too difficult and can merge some neighboring SOs into a single apparent pond. Often the single transect was not representative of the pond's surface water and depth, despite striving for representation. After the autumn monitoring session, the transect method to quantify surface water presence/absence and depth was discarded.

Although the 2022 method to quantify pond filling and drying was not repeatable for a given pond, between ponds, or by the surveyor, qualitative data was salvaged from the dataset (**Table 4**). It provides some data in 2022 on whether the pond filled and then dried, fully or partially. When combined with 2023 data it contributes information to the environmental conditions that affect Water Howellia's growth in 2023.

⁹ US Environmental Protection Agency's vernal pool definition and information found at: <https://www.epa.gov/wetlands/vernal-pools>

¹⁰ MTNHP Ecological System Field Guide: https://fieldguide.mt.gov/displayES_Detail.aspx?ES=9162

Table 4. Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
5	14-Jul-2022	Clear	Near full pool.											
	21-Sep-2022		dry											
	10-Jul-2023													
	No September Revisit													
8	13-Jul-2022	Clear	At or near full pool.											
	21-Sep-2022		dry											
	10-Jul-2023	Clear		50-98% Full	50-98% Full									
	20-Sep-2023			dry	dry									
15	13-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023	Clear		1-49% Full										
	21-Sep-2023	NA		dry										
18	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022		dry											
	12-Jul-2023	Murky		50-98% Full	50-98% Full	50-98% Full								
	20-Sep-2023			dry	dry	dry								
19	22-Jul-2022	Faintly Cloudy	Near or at full pool.											
	No September Revisit													
	13-Jul-2023	Faintly Cloudy		50-98% Full										
	20-Sep-2023	NA		dry	dry	dry	dry							
23	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Clear	50% of pond has water											
	13-Jul-2023	Clear		1-49% Full										
	20-Sep-2023	NA		dry										

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
26	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022		dry											
	9-Jul-2023	Clear		50-98% Full	1-49% Full									
	20-Sep-2023	NA		dry	dry									
27	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Clear	Less than 50% of pond has water											
	9-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full								
	20-Sep-2023			dry	dry	dry								
36	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		50-98% Full										
	19-Sep-2023	NA		dry										
38	14-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full						
	19-Sep-2023	NA		dry	dry	dry	dry	dry						
44	21-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022													
	17-Jul-2023	Clear		50-98% Full	50-98% Full									
	19-Sep-2023	Murky		1-49% Full	dry									
47	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	12-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full								
	19-Sep-2023	NA		dry	dry	1-49% Full								

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
60	13-Jul-2022	Clear	At or above full pool.											
	No September Revisit													
	12-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full						
	No September Revisit													
65	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	13-Jul-2023	Faintly Cloudy		50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full			
	20-Sep-2023	NA		dry										
69	13-Jul-2022	Murky	Near or at full pool.											
	21-Sep-2022	Faintly Cloudy	Less than 50% of pond has water											
	11-Jul-2023	Murky		50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full						
	19-Sep-2023	Faintly Cloudy		1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full						
74	13-Jul-2022	Murky	Near or at full pool.											
	21-Sep-2022													
	11-Jul-2023	Murky		full	full									
	19-Sep-2023	Faintly Cloudy		50-98% Full	50-98% Full									
78	13-Jul-2022	Clear	At or above full pool.											
	20-Sep-2022													
	12-Jul-2023	Clear		50-98% Full	50-98% Full									
	20-Sep-2023	NA		dry	dry									

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
86	14-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022													
	12-Jul-2023	Clear		1-49% Full	1-49% Full									
	20-Sep-2023	NA		dry	dry									
93	14-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023	Faintly Cloudy		50-98% Full										
	No September Revisit													
108	13-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022		dry											
	11-Jul-2023	Clear		1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full			
	20-Sep-2023	NA		dry	dry	dry	dry	dry	dry	dry	dry			
111	12-Jul-2022	Murky	Near or at full pool.											
	20-Sep-2022													
	13-Jul-2023			dry										
	19-Sep-2023	NA		dry										
123	16-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		50-98% Full	1-49% Full									
	19-Sep-2023	Clear		1-49% Full	1-49% Full									
126	15-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		50-98% Full										
	19-Sep-2023	Clear		1-49% Full										

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
129	14-Jul-2022	Faintly Cloudy	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		1-49% Full	50-98% Full	50-98% Full								
	19-Sep-2023	Murky		dry	1-49% Full	1-49% Full								
130	13-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022		dry											
	10-Jul-2023	Clear		50-98% Full	50-98% Full									
	21-Sep-2023	NA		dry	dry									
134	14-Jul-2022	Clear	At or above full pool.											
	21-Sep-2022		dry											
	10-Jul-2023	Clear		1-49% Full										
	21-Sep-2023	NA		dry										
135	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022		dry											
	9-Jul-2023			dry	dry									
	20-Sep-2023	NA		dry	dry									
137	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	No September Revisit													
	11-Jul-2023	Faintly Cloudy		full										
	19-Sep-2023	NA		dry										
138	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	12-Jul-2023			dry										
	20-Sep-2023	NA		dry										

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
140	22-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	13-Jul-2023			50-98% Full	50-98% Full	50-98% Full	50-98% Full							
	20-Sep-2023	NA		dry										
143	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022		dry											
	13-Jul-2023	Clear		1-49% Full										
	20-Sep-2023	NA		dry										
146	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	11-Jul-2023	Murky		50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full	50-98% Full			
	20-Sep-2023	NA		dry	dry	dry	dry	dry	dry	dry	dry			
147	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	11-Jul-2023	Murky		50-98% Full	50-98% Full	50-98% Full								
	20-Sep-2023	NA		dry	dry	dry								
155	12-Jul-2022	Faintly Cloudy	Near or at full pool.											
	20-Sep-2022		dry											
	12-Jul-2023	Murky		1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full				
	20-Sep-2023	NA		dry	dry	dry	dry	dry	dry	dry				
157	22-Sep-2022	Murky	Near or at full pool.											
	No September Revisit						50-98% Full							
	13-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full								
	20-Sep-2023	NA		dry	dry	dry	dry							

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
160	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	No September Revisit													
	11-Jul-2023	Murky		1-49% Full	50-98% Full									
	No September Revisit													
162	13-Jul-2022	Murky	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	12-Jul-2023	Faintly Cloudy		1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full	1-49% Full
	20-Sep-2023			dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
164	12-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022		dry											
	11-Jul-2023	Faintly Cloudy		50-98% Full	50-98% Full	50-98% Full	50-98% Full							
	19-Sep-2023	NA		dry	dry	dry	dry							
165	12-Jul-2022	Faintly Cloudy	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	11-Jul-2023	Faintly Cloudy		full										
	19-Sep-2023	NA		dry										
172	12-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	11-Jul-2023	Faintly Cloudy		50-98% Full	50-98% Full									
	19-Sep-2023	NA		dry	dry									

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
173	12-Jul-2022	Faintly Cloudy	Near or at full pool.											
	No September Revisit													
	13-Jul-2023	Clear		50-98% Full										
	No September Revisit													
176	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	12-Jul-2023	Faintly Cloudy		50-98% Full	50-98% Full	50-98% Full								
	19-Sep-2023	NA		dry	dry	dry								
178	12-Jul-2022	Faintly Cloudy	Near or at full pool.											
	20-Sep-2022	Murky	Less than 50% of pond has water											
	12-Jul-2023	Faintly Cloudy		full										
	19-Sep-2023	Faintly Cloudy		50-98% Full										
179	13-Jul-2022	Murky	Near or at full pool.											
	21-Sep-2022													
	12-Jul-2023	Faintly Cloudy		50-98% Full										
	19-Sep-2023	NA		dry										
184	12-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023	Clear		1-49% Full	50-98% Full	50-98% Full								
	20-Sep-2023	Clear		dry	1-49% Full	dry								

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
186	14-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022	Dry	dry											
	13-Jul-2023	Clear		1-49% Full	1-49% Full									
	19-Sep-2023	NA		dry	dry									
188	14-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022	Clear												
	12-Jul-2023	Clear		50-98% Full										
	20-Sep-2023	NA		dry										
190	13-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023			50-98% Full										
	No September Revisit													
191	14-Jul-2022	Clear	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	11-Jul-2023	Faintly Cloudy		full										
	19-Sep-2023	NA		dry										
195	13-Jul-2022	Faintly Cloudy	Near or at full pool.											
	20-Sep-2022	Dry	dry											
	11-Jul-2023	Clear		full										
	19-Sep-2023			dry										
209	13-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full	50-98% Full							
	20-Sep-2023	NA		dry	dry	dry	dry							

Table 4 (continued). Summer and autumn pond hydrology for 54 monitored Water *Howellia* Species Occurrences (SOs) in 2022 and 2023.

SO #	Monitoring Date	Water Clarity	2022 Qualitative Pond Surface Water	2023 – Percentage of Surface Water in Pond Section										
				S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
211	13-Jul-2022	Clear	Near or at full pool.											
	No September Revisit													
	12-Jul-2023	Clear		50-98% Full	50-98% Full	50-98% Full	50-98% Full							
	20-Sep-2023	NA		dry	dry	dry	dry							
215	13-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022		dry											
	11-Jul-2023	Clear		1-49% Full										
	21-Sep-2023	NA		dry										
216	13-Jul-2022	Clear	Near or at full pool.											
	21-Sep-2022		dry											
	11-Jul-2023	Clear		50-98% Full										
	21-Sep-2023	NA		dry										

3.3.2 2023 Pond Hydrology

In 2023 the revised method assessed the pond's surface water at the quarter-acre section in both the summer and autumn monitoring sessions (**Table 4**). This assesses hydrology at the same scale done for Water Howellia and Reed Canarygrass, and makes the method more repeatable, quantifiable, and useful.

In 2023, general pond hydrology was drier than in 2022. The July summer session found 3 of the 54 Water Howellia SOs to be dry. The vast majority of surface water in the vast majority of SOs had drawn down by September in 2022 and 2023. Only two SOs in both 2022 and 2023 retained a significant amount of water in a portion of their basins; it is assumed that they receive more groundwater than other ponds.

3.3 Ambient Temperature Monitoring

Ambient temperature loggers were placed at three primary PDM Water Howellia SOs in 2023 (**Table 1; Figures B1-B7 in Appendix B**):

- SO-ID 5000108: Northern zone in Cilly Creek area
- SO-ID 5000018: Eastern zone in Condon Loop area
- SO-ID 5000038: Southern zone in the Kraft Creek area

The intent was to record ambient temperature throughout the growing season because it is one environmental variable that affects pond drying. The temperature loggers recorded data for only a single growing season (2023), which is not enough time to relate with Water Howellia abundance data. Both the 2022 summer temperature data and 2022-2023 precipitation levels are needed to analyze with the 2023 plant abundance data. The 2023 ambient temperature data provides a baseline upon which to compare with future monitoring data for both temperature, Water Howellia abundances, and pond filling/drying during the 15-year monitoring window.

The iButton loggers recorded ambient temperature from May 10th to November 16th in 2023. For reference, summer and autumn monitoring took place from July 11th to 13th and September 20th to 22nd in the vicinity of these loggers. Within the 24-hour period ambient temperature was summarized by 'day' and 'night' hours. Day length went from sunrise to sunset but was adjusted each month to account for the progression of the season. Night length went from sunset to sunrise and was also adjusted for each month. The time of sunrise and sunset reported by the National Oceanic and Atmospheric Administration's (NOAA) solar calculator was used for this summary (**Table 5**). Averages in ambient temperature were calculated based on the number of recorded days in each month and the number of day-length and night-length hours (**Table 5**).

Table 5. The calculated and applied times for sunrise and sunset, number of temperature recorded days each month, and hours of day and night used in the Water Howellia monitoring study in 2023.

Metrics Used in Monitoring Study	Months of Recorded Temperature in 2023						
	May	Jun	Jul	Aug	Sep	Oct	Nov
Reported Sunrise Time ¹	5:58 AM	5:37 AM	5:53 AM	6:31 AM	7:12 AM	7:54 AM	7:40 AM
Applied Sunrise Time	6:00 AM	5:30 AM	6:00 AM	6:30 AM	7:15 AM	8:00 AM	7:45 AM
Reported Sunset Time ¹	8:06 PM	8:35 PM	8:29 PM	7:47 PM	6:47 PM	5:47 PM	4:59 PM
Applied Sunset Time	8:00 PM	8:30 PM	8:30 PM	7:45 PM	6:45 PM	5:45 PM	5:00 PM
Number of Days with Recorded Temperatures	21	30	31	31	30	31	16
Number of day Length Hours	14	15	14.5	13.25	11.5	9.75	9.25
Number of night Length Hours	10	9	9.5	10.75	12.5	14.25	14.75

¹ Calculated by the National Oceanic and Atmospheric Administration (NOAA) Solar Calculator.

Temperature data from the iButton loggers was charted for Water Howellia SOs at Cilly Creek, Condon Loop, and Kraft Creek areas. Based on the number of days in the month, average ambient temperatures for daytime, nighttime, and in a 24-hour period along with the 24-hour minimum and maximum temperatures were charted from the three loggers (**Figures 10 to 12**). In this report the information is presented with no summarized remarks.

Figure 10. Monthly average ambient temperatures for day-length, night-length, and 24-hour periods with the monthly maximum and minimum temperatures recorded at Water Howellia SO-Num 108 in the Cilly Creek area in 2023.

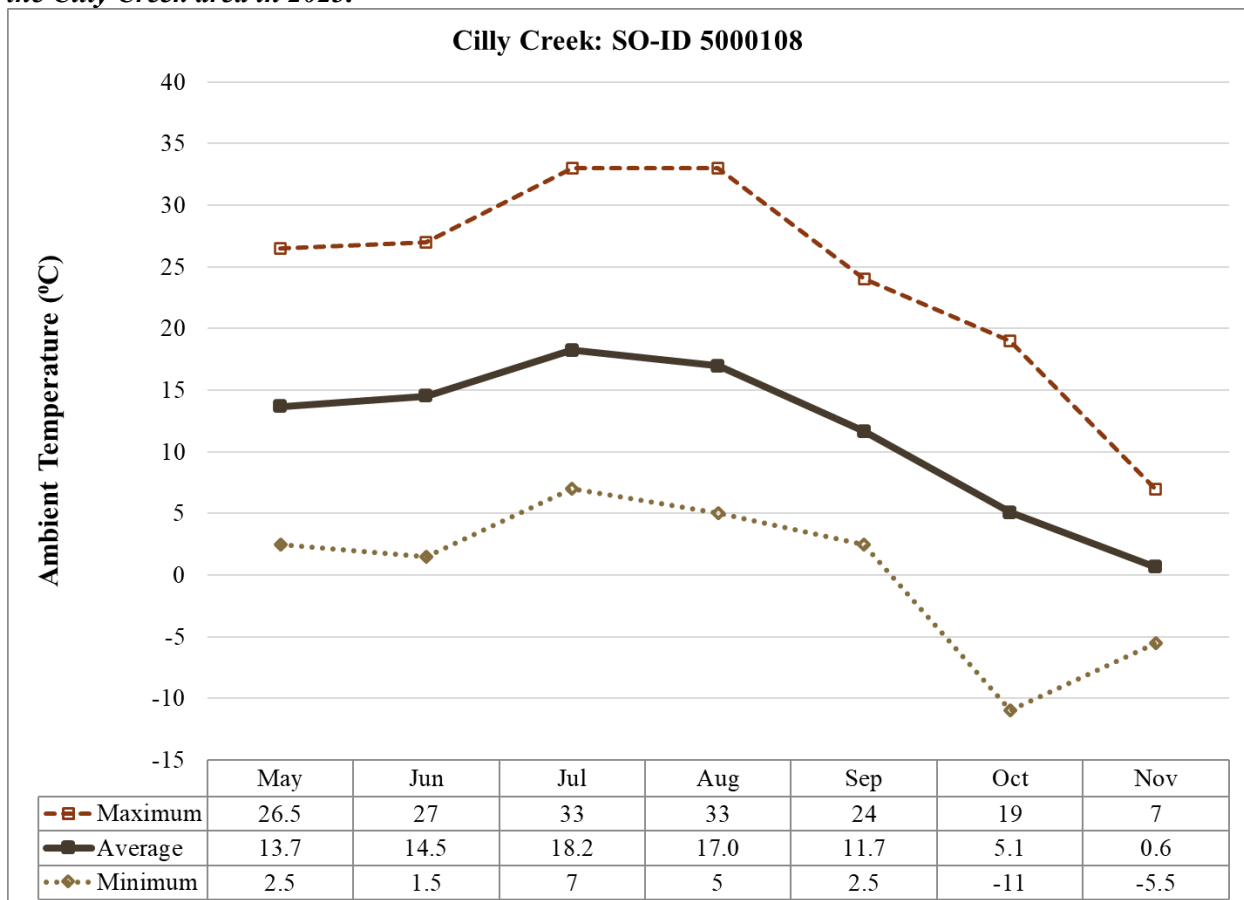


Figure 11. Monthly average ambient temperatures for day-length, night-length, and 24-hour periods with the monthly maximum and minimum temperatures recorded at Water Howellia SO-NUM 18 in the Condon Loop area in 2023.

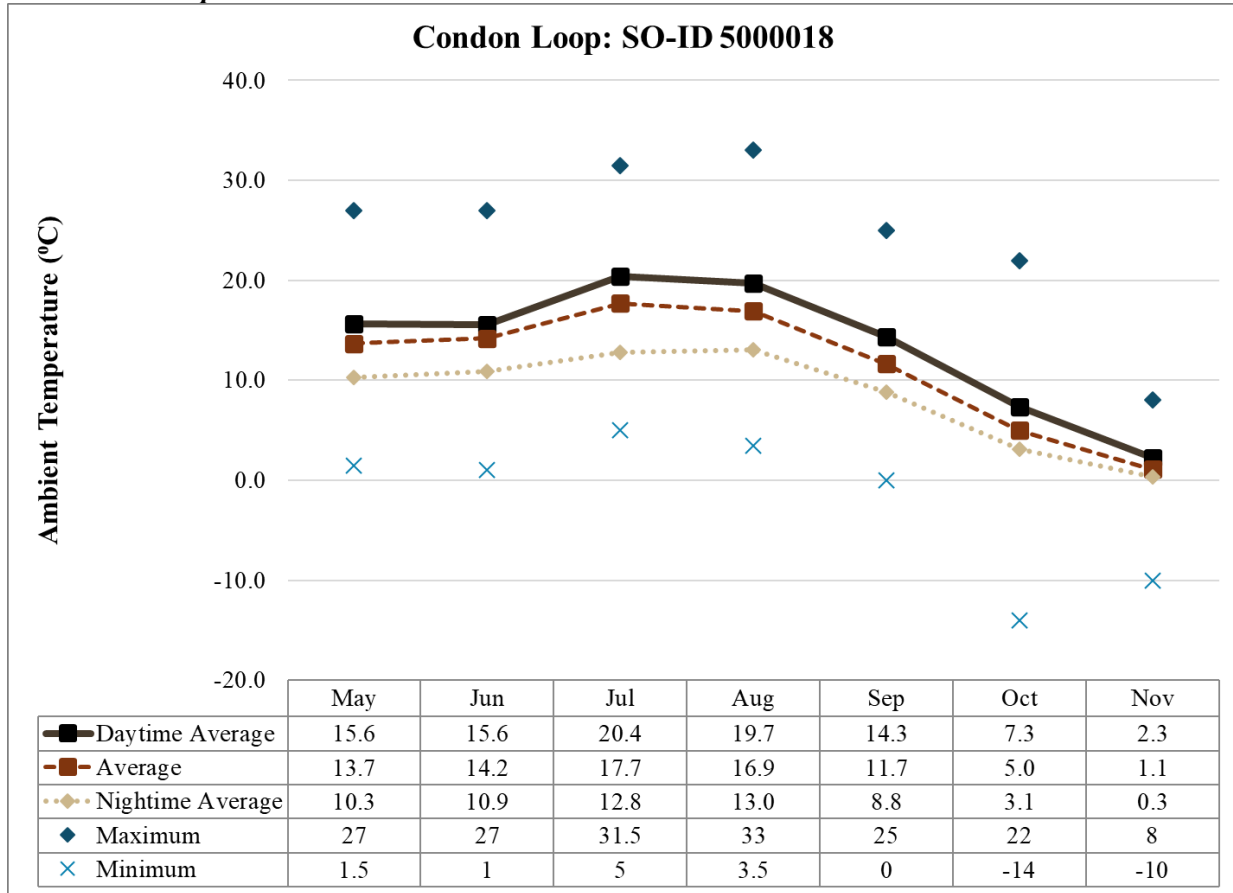
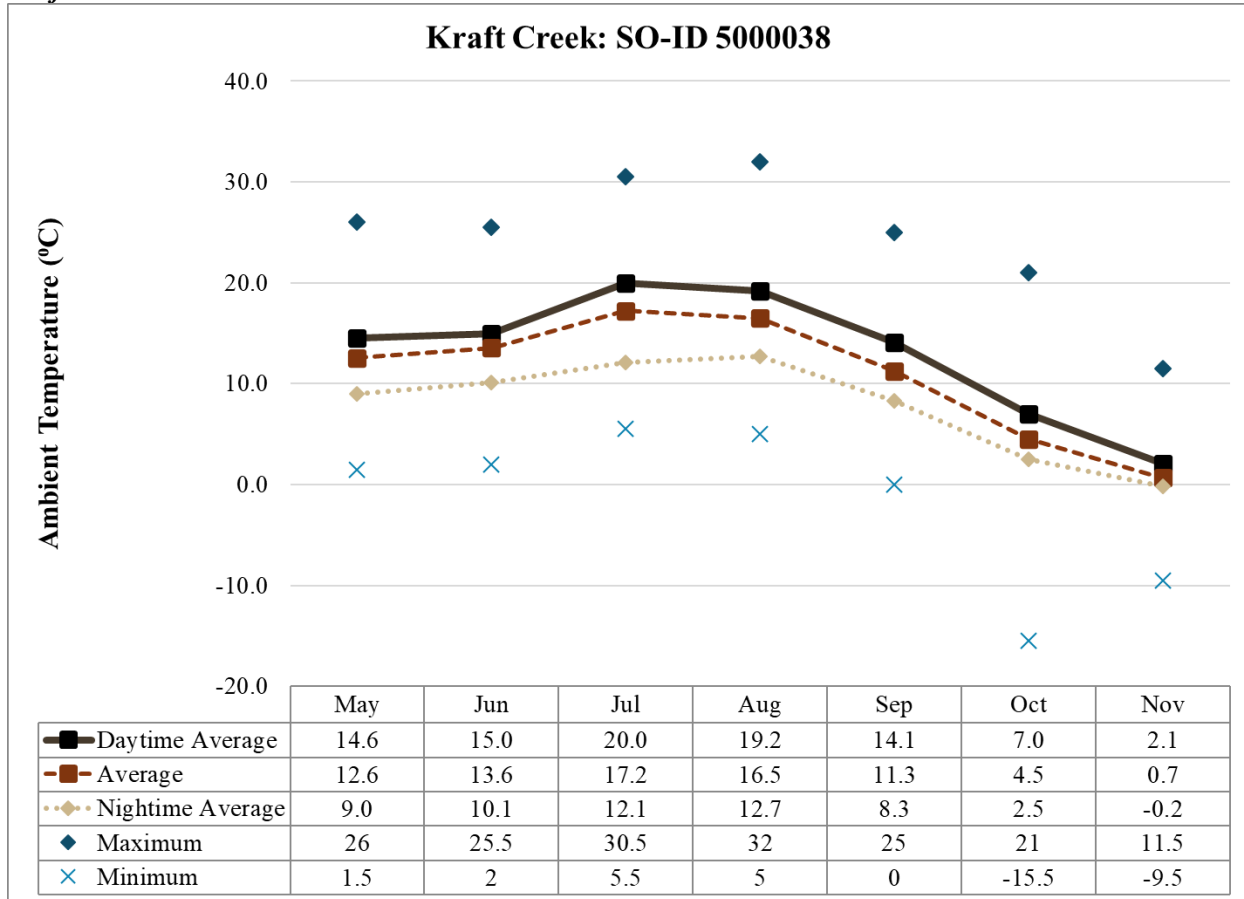


Figure 12. Monthly average ambient temperatures for day-length, night-length, and 24-hour periods with the monthly maximum and minimum temperatures recorded at Water Howellia SO-Num 38 in the Kraft Creek area in 2023.



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Appendix A

*Post-Delisting Monitoring Protocol for Montana
Paper Form & Instructions*

*Post-Delisting Monitoring Study for *Howellia aquatilis* (Water *Howellia*) in
Montana: Two-Year Baseline Assessment*

***HOWELLIA AQUATILIS* AND *PHALARIS ARUNDINACEA* MONITORING INSTRUCTIONS**

The purpose is to revisit ponds where *Howellia aquatilis* (Water Howellia) has been documented, in order to collect current plant, habitat, and hydrological data, correct any mapping, and photograph conditions. This information is housed by the Montana Natural Heritage Program, is publicly available, used to track the status of *Howellia aquatilis* and assist in other stewardship actions, and is shared with government agencies and other landowners.

PROCEDURES

Ideally people work in pairs to access and survey the pond and conduct monitoring. The *Howellia aquatilis* Monitoring and *Howellia Fall Drying Transect* forms in Survey123 are used to collect data, map locations, and photograph conditions. Alternatively, hardcopy monitoring forms, a camera, and a GPS unit, or similar devices, can be used to collect data, photograph, and map locations. Survey with waders or similar gear to protect yourself from leaches, pointy sticks, etc.

Each pond is tracked by a Species Occurrence number (SO-NUM) and identification number (SO-ID). Each pond is divided into sections that are approximately 0.25 acre in size, and assigned a consecutive number (S1, S2, S3, etc.), which is drawn on the hardcopy map of the pond.

General Pond Information

SO-ID: Obtain from the provided pond map.

Camera/GPS: If not using Survey123 app, the model/description to match photos with data.

Observer's Name(s): Full first and last names for the primary, and secondary, observer(s).

Observation Date: The month, day, and year when the pond was monitored.

Start and End Times: Time when monitoring started and ended. Survey123 will automatically complete start time and date, which can also be manually changed.

Datum: The coordinate system (WGS84, NAD,27, etc.) being used to determine the latitude and longitude locations. This is essential to make sure points and polygons map properly.

SO Located? Indicate if you found the SO or not. If unsure mark “no” and explain. Be honest.

Latitude/Longitude: Write the coordinates or mark a point to indicate your general location at the SO was found or not located.

Weather: Concisely describe the weather. This helps provide context that might explain the quality of data collected, ability to find the plant, etc.

Number of Sections: If using Survey123 form put in the number of pond sections displayed on your map.

Lock Site Info Above: If using Survey123 form, click ‘yes’ to prevent data loss while surveying.

Surveying The Pond Section For Plants

Meander through a section to search for *Howellia aquatilis*, *Phalaris arundinacea* (Reed Canary Grass), total Submergent Aquatic Vegetation, and total Emergent Aquatic Vegetation (minus *Howellia aquatilis*), until you can make a confident determination of abundance* using the categories provided on the form. NOTE that *Howellia aquatilis* is by plant number and *Phalaris aquatilis*, Emergent, and Submergent vegetation is by percent cover where the specific Section equals 100%. Refer to the hardcopy monitoring form for guidance on *Howellia* numbers; counting plants is only needed for initially calibrating one's eyes.

Complete one section at a time, paying attention to section lines.

Submergent Vegetation includes all plant material that grows below the water surface, excluding *Howellia aquatilis*, and without regard to the species' growth form; it provides an idea of competition in the water and ability to track changes in underwater vegetative changes.

Emergent Vegetation includes all plant material that is on or above the pond surface, and without regard to the species' growth form; it is a measure of competition for sun that lies on and above the water surface, and provides the ability to track ‘above-water’ vegetative changes.

Aquatic Vegetation Assessment Comments: Write any comment that pertains to emergent and submergent vegetation.

Drawing On The Pond Map

Draw either on the hardcopy pond image/aerial or sketch in the Survey123 form where *Howellia aquatilis* and *Phalaris arundinacea* generally are found in the pond.

In the Survey123 form, check sketch and then tap on the sketch symbol to open the pond map [right figure]. Use the features to zoom and draw a general polygon for where HOAQ (*Howellia aquatilis*) and/or PHAR (*Phalaris arundinacea*) occur:



Tap symbol to zoom and move the image to where you want to draw.



Tap to create polygon and then choose HOAQ or PHAR. Tap finger to create polygon.



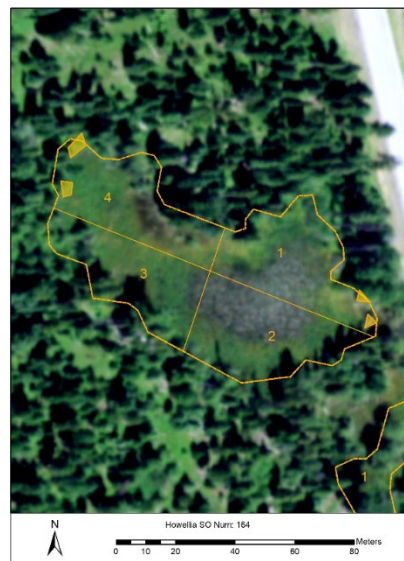
Tap to save polygon, and note the symbol changes to only a checkmark.



Tap to undo and re-do, respectively, a past action



Once saved or to exit, tap the back arrow to return to the form.



Pond Site Information

Complete the following fields after all pond sections have been surveyed.

Water Clarity: Select the best category to describe how clear the pond water is

Cattle Use: Select the best category to describe if cattle use (animals, dung, trampling, etc.) was observed.

Howellia aquatilis Phenology: Check all that you observed in the pond.

Photographs

Photographs that capture the following elements are needed to help document presence, accuracy in identification, changes in site conditions, and to relay information gained by the observer to other users of the data.

NOTE:

- The Survey123 form has specific sections for capturing *Howellia aquatilis*, *Phalaris arundinacea*, and site types of photographs. In other words, try not to purposely photograph “pond habitat” in the section for photographing *Howellia aquatilis*.
- The hardcopy form asks for a description of what the photo captures and a lat/long location where it was taken.

Site Photographs

Take 2-5 photographs to capture the pond, habitat, and hydrological conditions. IDEALLY, each pond should be photographed from 2-4 cardinal directions by standing near the edge and shooting towards pond center. NOTE: There are options to view, rotate, and rename the photo. **Do NOT RENAME the photo because the software is formatted to pull information from other fields to create the file name;** you will not see the actual formatted file name.

For each photo, complete the following information:

Location of Photo: Record or mark the location of the photo.

Direction of Photo: Record or mark the direction that photo is being taken.

Pond Section: If photo is documenting a quarter-acre section then record or click the section number.

Comments: Write a description or make comments on what the photo captures. Write other comments pertaining to what is being photographed, if necessary.

Howellia aquatilis: If possible, take at least one photo to document the presence of *Howellia aquatilis*, which includes identifiable characteristics. If warranted, take additional photos of the plant (not habitat).

Phalaris arundinacea: If possible, take at least one photo to document the presence of *Phalaris arundinacea*, which includes identifiable characteristics. If warranted, take additional photos of the plant (not habitat).

Weeds: Photograph noxious and exotic species. Capturing identifiable traits either in words (comments) or photographs.

Weeds

Survey for noxious weeds and check the box for any that appear in the list. For those not listed check “other” and provide the name in the comment box. Photograph the plant along with its identifiable characteristics. Write in the comments any characteristics that you observed, but cannot be photographed (Example, Found black hairs on the sepals). NOTE: Aquatic exotic and noxious plants should be surveyed for.

Surface Water Assessment

Assess the amount of surface water present in each section. Determine the location of the high-water mark. Glistening soil indicates saturation, but is not considered surface water. Human or animal footprints that fill in with water are not considered surface water. Write any necessary comments about hydrology or surface water.

Summary of Survey

Record the time when you complete the survey. Record the total time spent surveying by calculating the survey time by the number of surveyors. Write any final comments about any aspect of the monitoring.

THANK YOU

for contributing information on the status and condition of *Howellia aquatilis*!

Howellia aquatilis and *Phalaris arundinacea* Monitoring

Species Occurrence (SO)-ID: _____ Camera: _____ GPS: _____

Observer's Name(s) (first & last): _____ ; _____

Observation Date(s): ____ / ____ / ____ ; _____ Start Time: _____ End Time: _____
month day year

Datum: _____ SO located? Y / N _____ Latitude, _____ Longitude

Weather: _____

HOWELLIA AQUATILIS (mark with X to select a single, best response)

Low = hard to find, less than 50 plants

Moderate = no trouble seeing plants, but sparse, around 50 -100 or so plants

High = no trouble finding plants, hundred of individuals, but can't count them anymore because they are so intertwined.

Section Number	None No plants found	Low 1-49 plants present	Moderate 50-100 plants present	High 101 or more plants present	Not Surveyed Explain in Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

PHALARIS ARUNDINACEA (mark with X to select a single, best response)

Low = 0-25% cover = Low

Moderate = 25-50% cover

High = greater than 50% cover

Section Number	None No plants found	Low 1-25% cover	Moderate 25-50% cover	High 50% or more cover	Not Surveyed Explain in Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

SO-ID: _____

Date (M/D/YEAR): ____ / ____ / ____

Howellia aquatilis Phenology found (select):

- ☐ Surface Flowers
☐ Fruiting
☐ Underwater Flowers
☐ Vegetative (leaves/stems) only

Howellia aquatilis Comments: threats, problems with assessment, etc.**Photograph SO:** Stand near edge and photograph towards center at 1-4 locations

Photo Number _____ Description: _____

_____ Latitude _____ Longitude

Photo Number _____ Description: _____

_____ Latitude _____ Longitude

Photo Number _____ Description: _____

_____ Latitude _____ Longitude

Photo Number _____ Description: _____

_____ Latitude _____ Longitude

Phalaris arundinacea Comments:

Submergent Aquatic Vegetation: Estimate percent submerged vegetation coverage by section (excluding Water Howellia).

Section Number	None (0%) No plants found	Low 1-25% present	Moderate 26-50% present	High 51-75% present	Very High 76-100% present.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Emergent Aquatic Vegetation: Estimate percent emergent vegetation coverage by section (excluding Water Howellia).

Section Number	None (0%) No plants found	Low 1-25% present	Moderate 26-50% present	High 51-75% present	Very High 76-100% present.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Surface Water: Assess the percentage of surface water that covers each section.

Section Number	Above High Water Mark	Full: At High Water Mark	50% to 98% Full	2% to 49% Full	Dry: No Surface Water
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Final Comments (survey effort, other plants, animal use, disturbance, etc.)

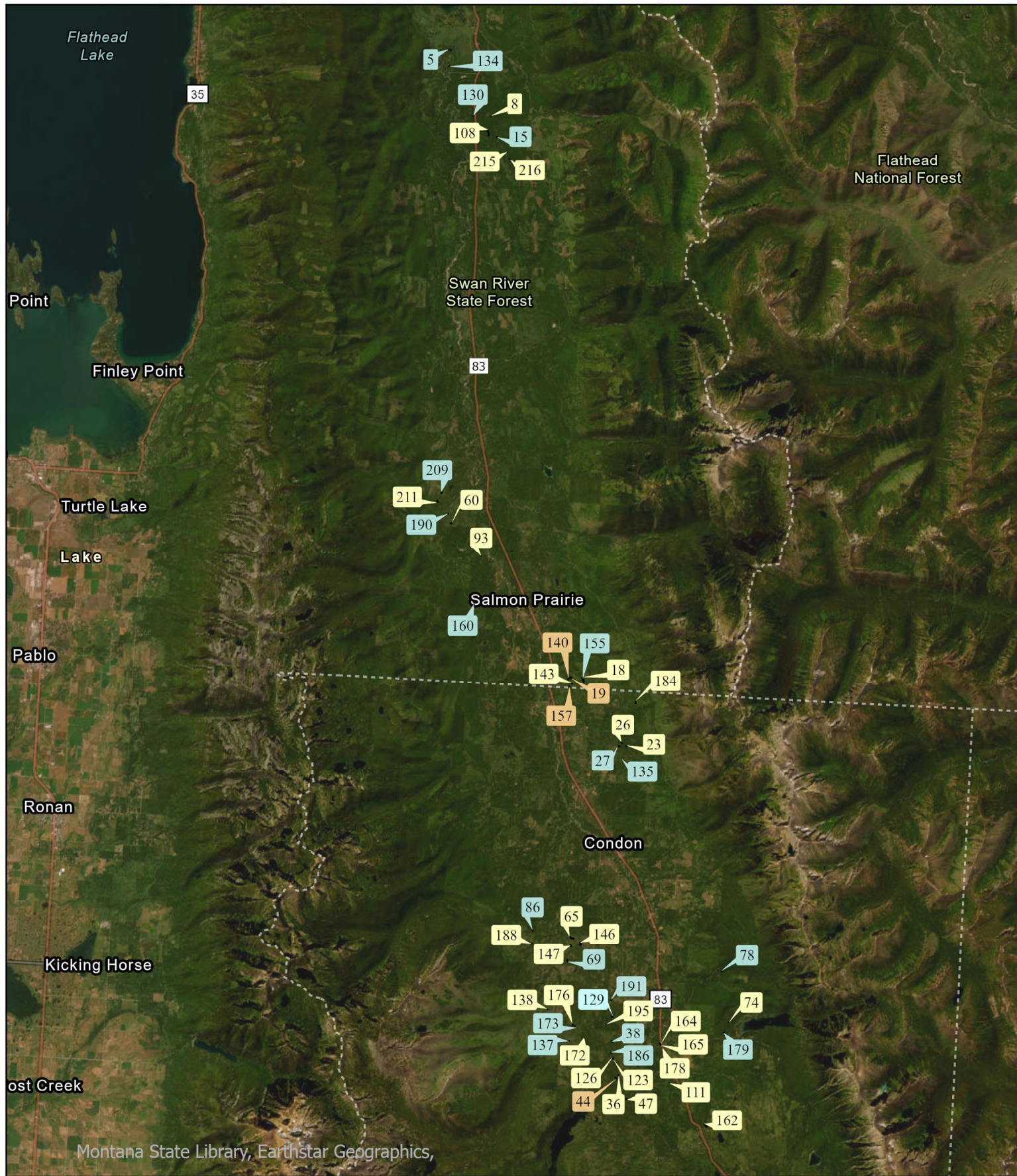
Appendix B

Maps of Monitored Water Howellia Species Occurrences

Figure B1: Overview

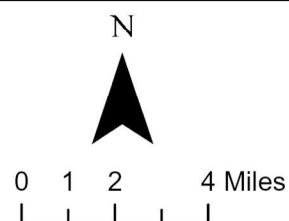
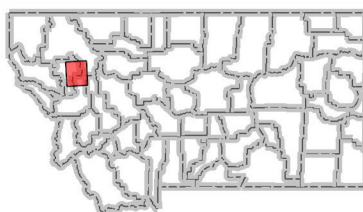
Figures B2 – B7: Monitored Ponds

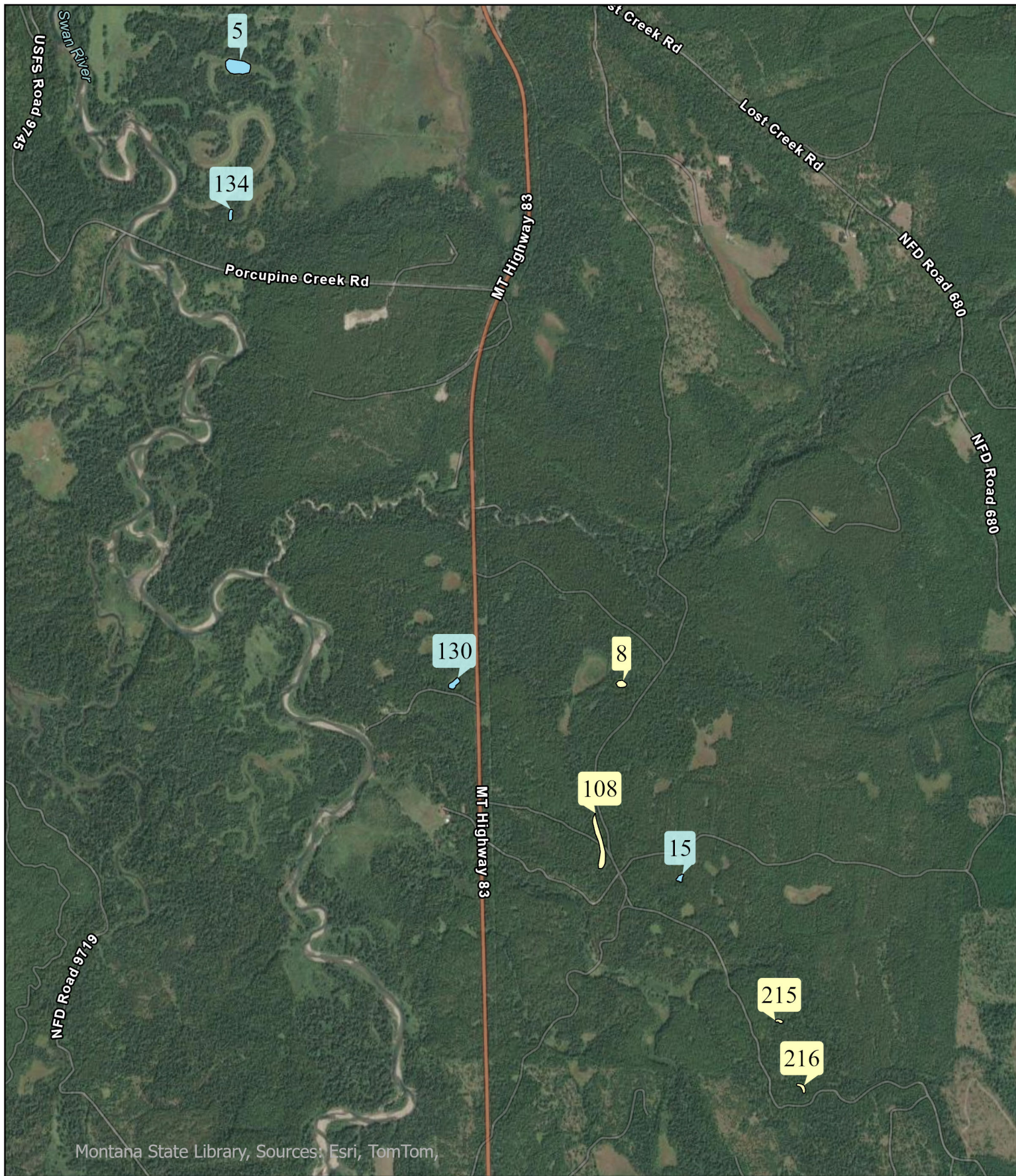
*Post-Delisting Monitoring Study for Howellia aquatilis (Water Howellia) in
Montana: Two-Year Baseline Assessment*



Howellia aquatilis
Post-Delisting Monitoring Ponds

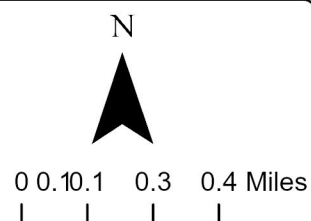
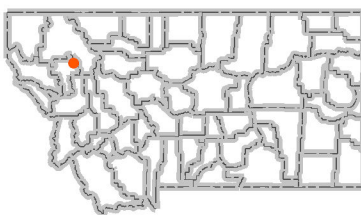
- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond

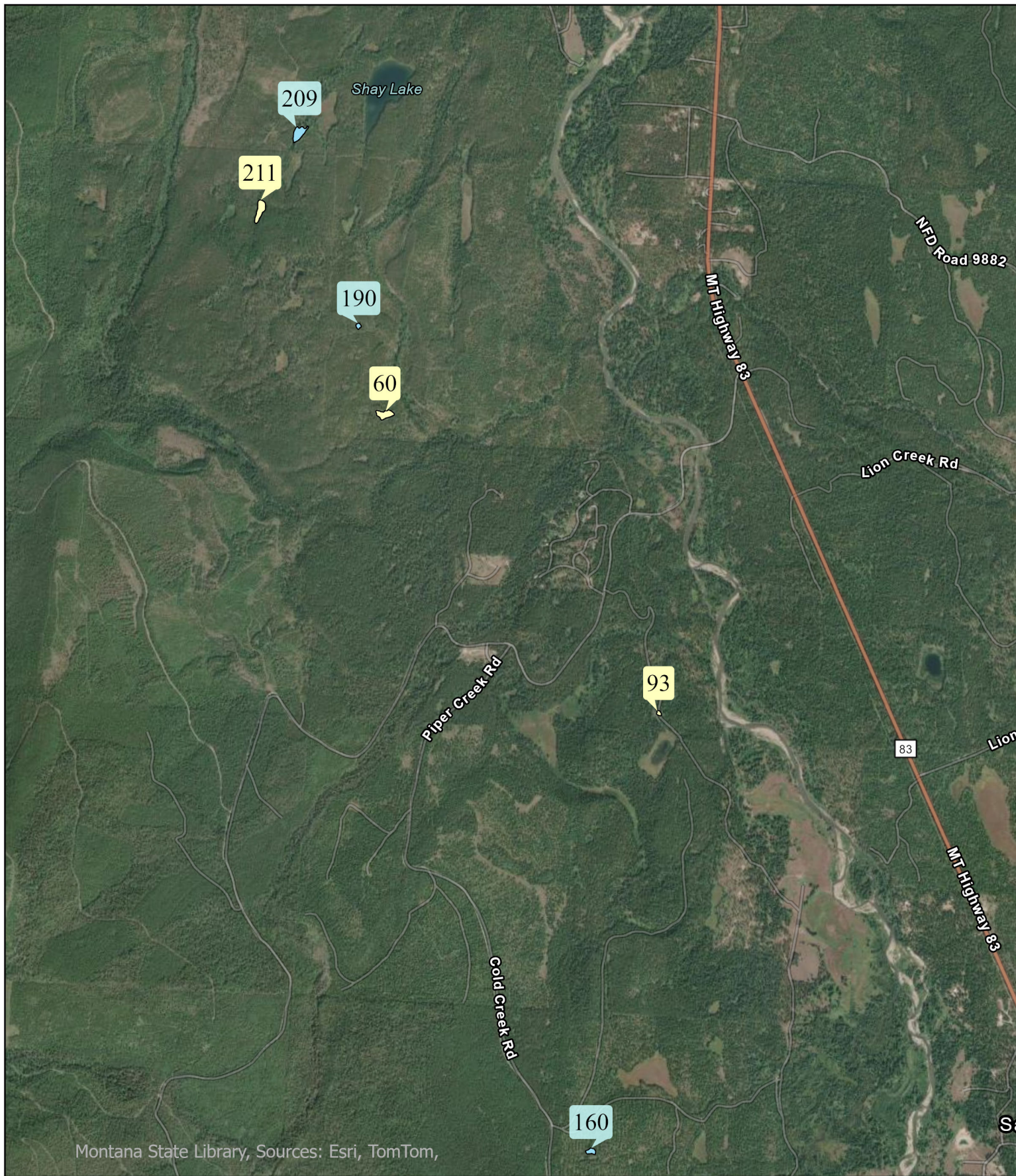




Howellia aquatilis
Post-Delisting Monitoring Ponds

- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond

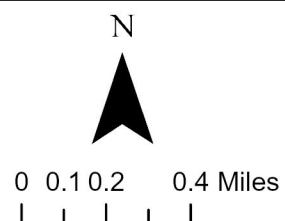
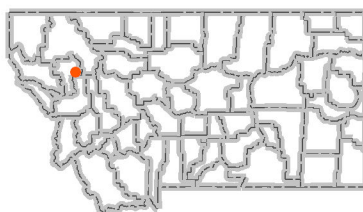


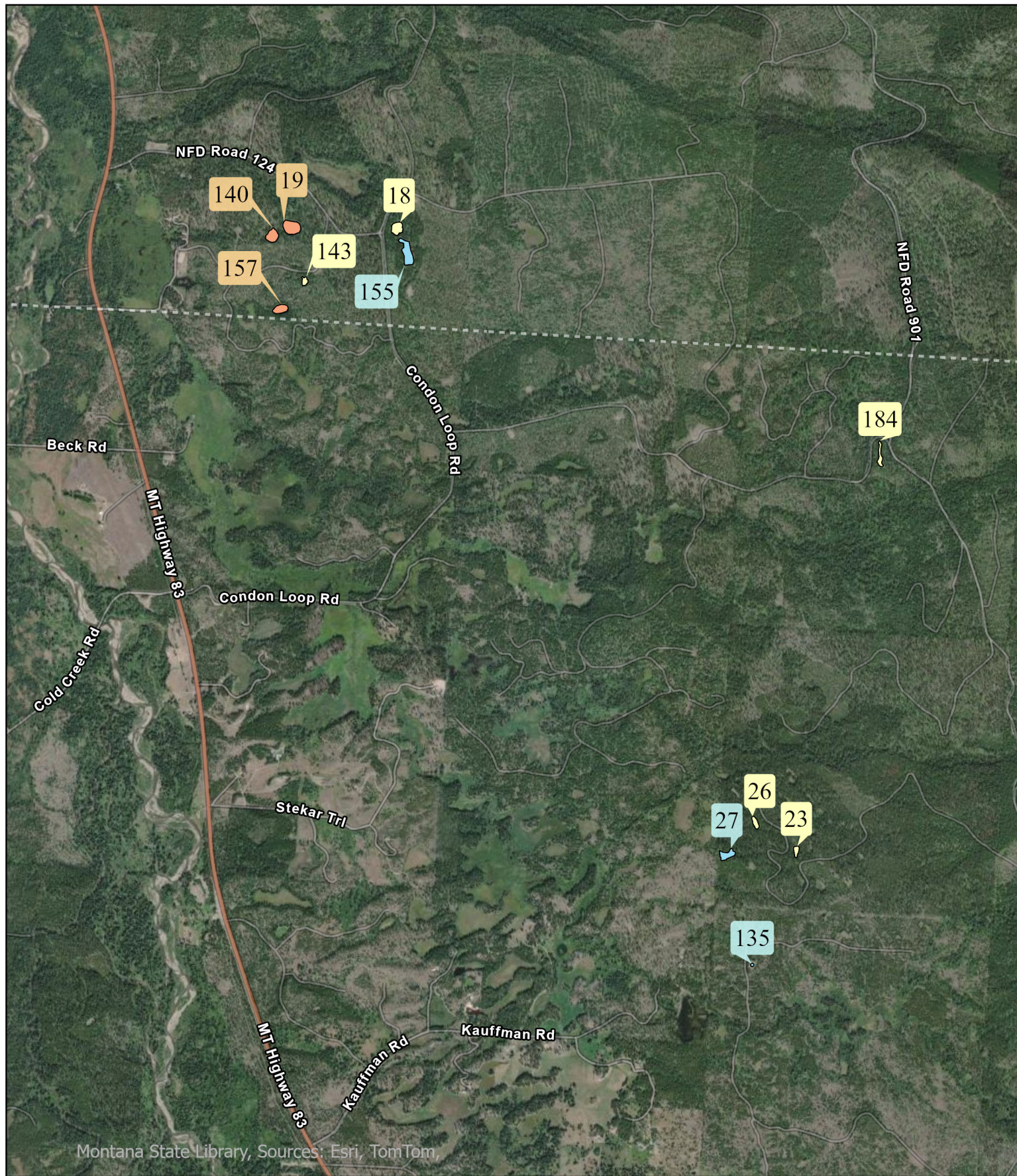


Howellia aquatilis

Post-Delisting Monitoring Ponds

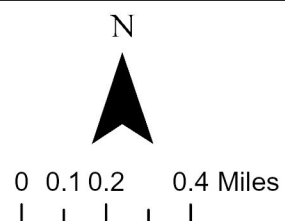
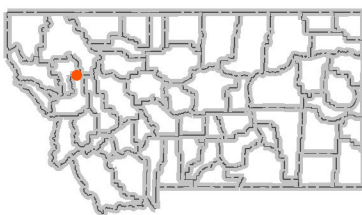
- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond





Howellia aquatilis
Post-Delisting Monitoring Ponds

- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond

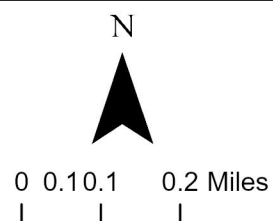
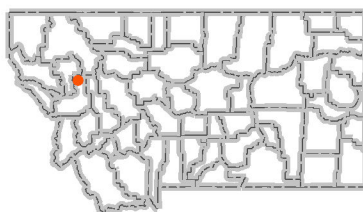


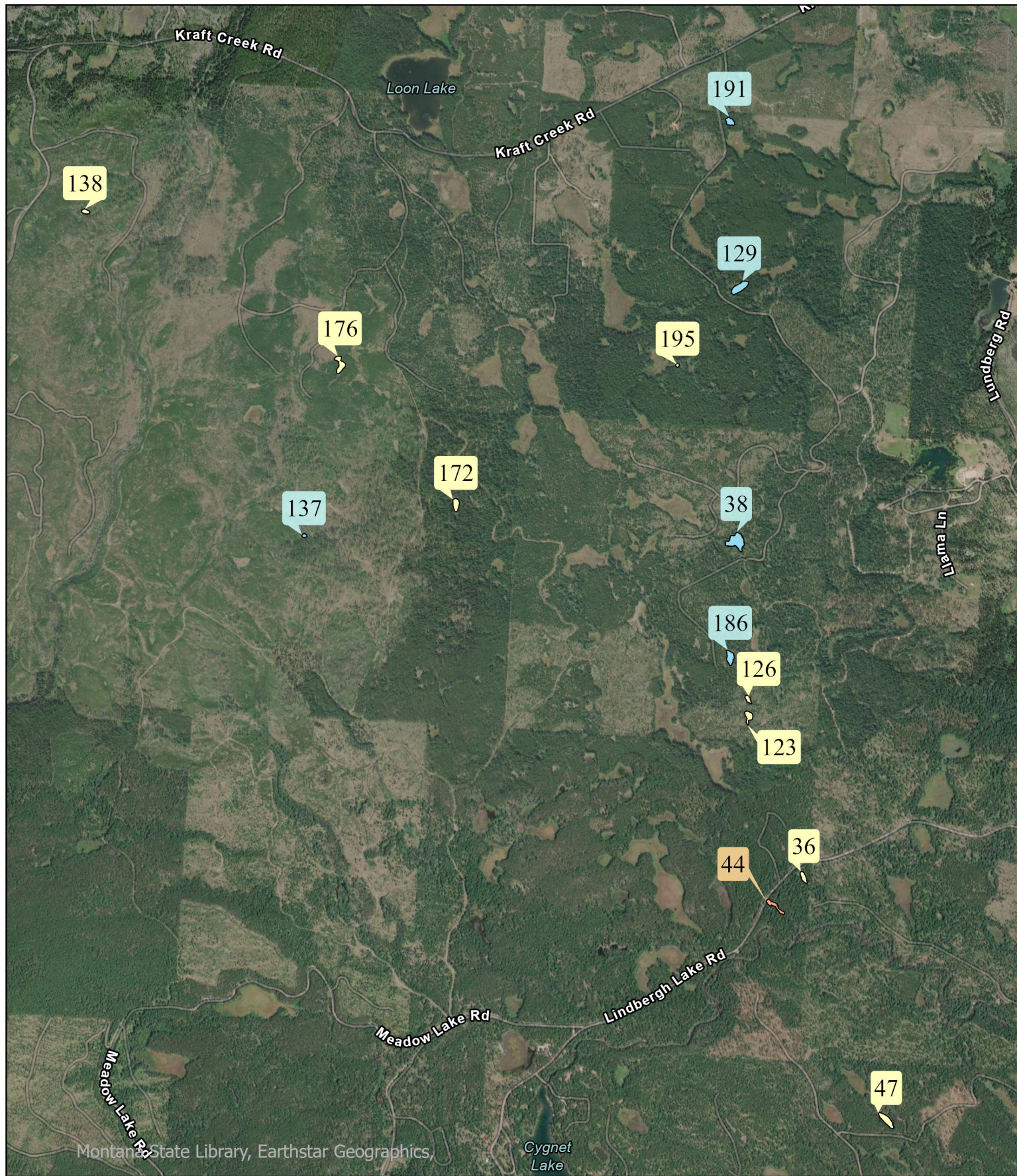


Howellia aquatilis

Post-Delisting Monitoring Ponds

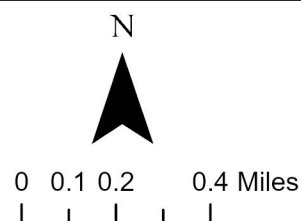
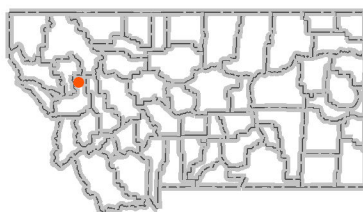
- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond





Howellia aquatilis
Post-Delisting Monitoring Ponds

- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond

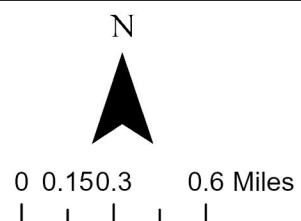
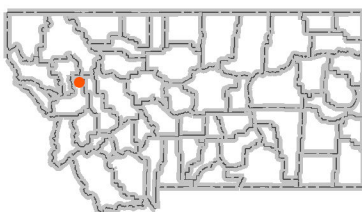




Montana State Library, Sources: Esri, TomTom,

Howellia aquatilis
Post-Delisting Monitoring Ponds

- Primary PDM Pond
- Secondary PDM Pond
- Additional PDM Pond



Appendix C

Photographs of Monitored Water Howellia Species Occurrences in July and September 2022 to 2023

Post-Delisting Monitoring Study for Howellia aquatilis (Water Howellia) in Montana: Two-Year Baseline Assessment

**Appendix C - Baseline Monitoring Photographs:
PDM and Additional Water Howellia SOs in July and September of 2022 and 2023.**

NOTE: Appendices C1 to C8 are only electronically available from MTNHP as eight separate PDF Files.